Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

FIVE DOLLARS A YEAR

JANUARY 1955

25th Anniversary Issue

Science and Engineering—

today and tomorrow

Drawing silicon crystals for solar batteries

TOUGH SPOTS ARE GOOD SPOTS FOR SIRVENE

A tasteless, odorless gasket for a pressure cooker lid . . . a gear box seal for an automatic ironer . . . a tub seal for a washer . . . there are countless places where Sirvene (synthetic rubber) is used in home appliances. Each is a specially engineered problem involving exact degrees of flexibility or hardness, with correct resistance to extreme temperatures, pressures, fluids, gases, abrasion and wear.

If you need a molded part of unusual design for a critical application, the unmatched experience of Sirvene engineers is at your service. They will assist you in design development, formulate the right compound, then produce the molded part in quantity with laboratory exactness. We will welcome the opportunity to work with you.

GET the basic information on this versatile material. "Engineering with Sirvene" will be sent on request at no charge.

C/R
SIRVENE
SCIENTIFICALLY COMPOUNDED ELASTOMERS

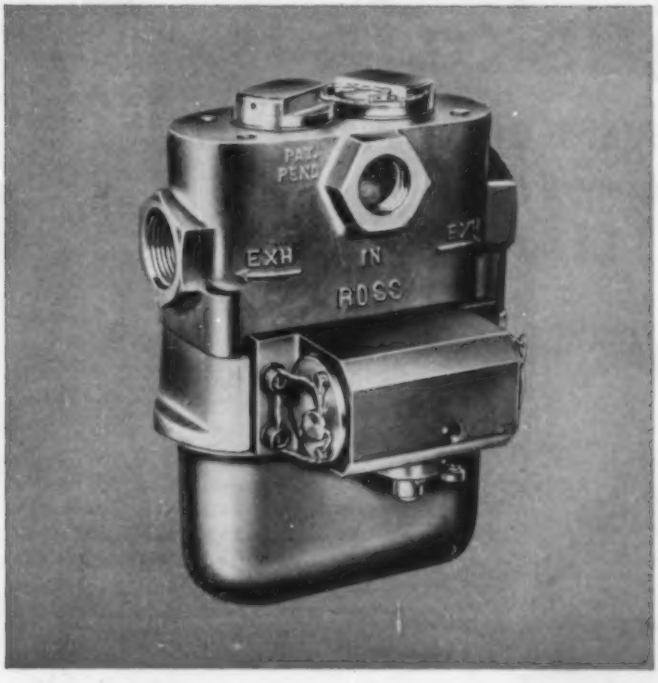
CHICAGO RAWHIDE MANUFACTURING COMPANY

1301 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

Other **C/R** *products*

OIL SEALS: Shaft and end face seals for all types of lubricant retention and dirt exclusion • CONPOR: Controlled porosity mechanical leather packings and other sealing products • SIRVIS: Mechanical leather boots, gaskets, packings and related products.

Ross LIFEGUARD



A NEW AIR CONTROL SOLENOID VALVE FOR

SAFER PRESS OPERATION

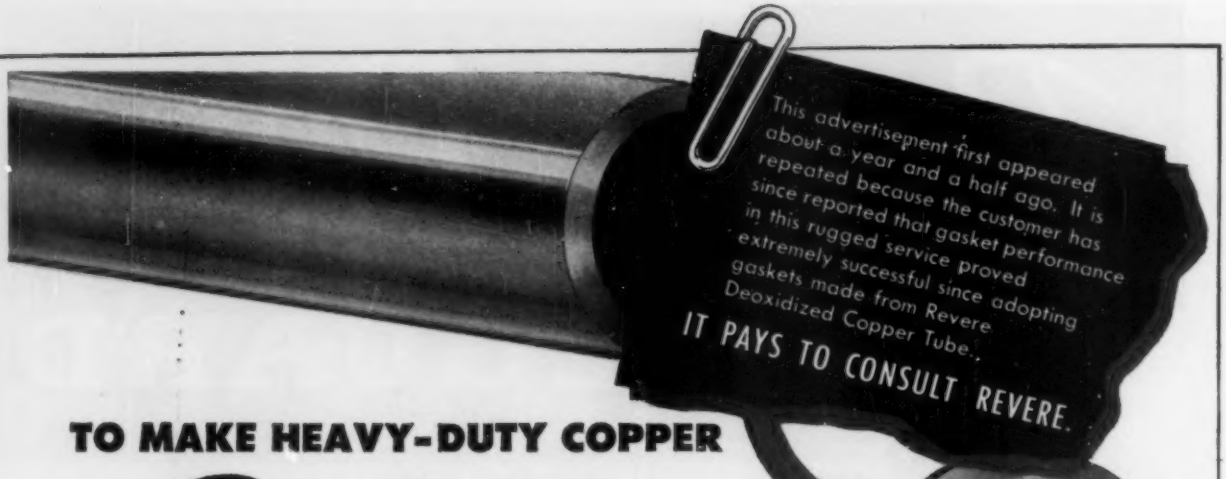
Write for Bulletin 306

Tomorrow's EnginAIRing Delivered Today

ROSS Control VALVES

Ross OPERATING VALVE COMPANY

120 E. GOLDEN GATE AVENUE • DETROIT 3 • MICHIGAN



This advertisement first appeared about a year and a half ago. It is repeated because the customer has since reported that gasket performance in this rugged service proved extremely successful since adopting gaskets made from Revere Deoxidized Copper Tube.

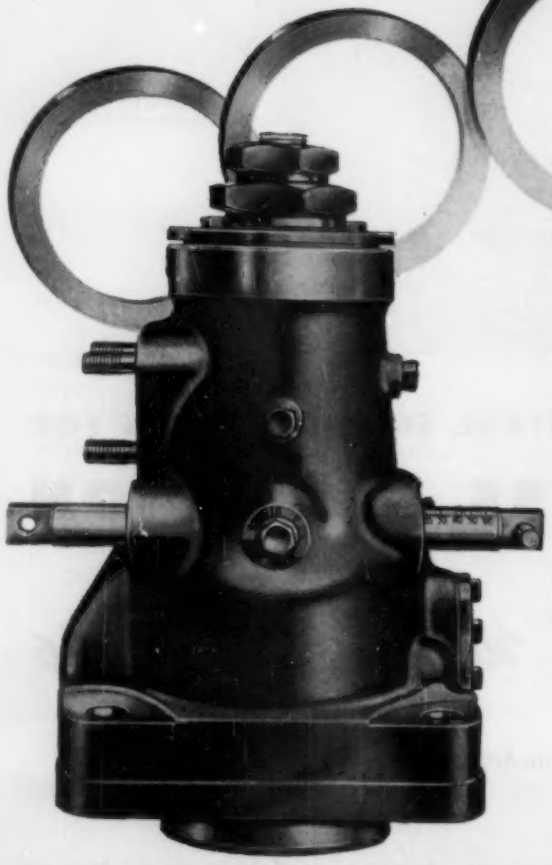
IT PAYS TO CONSULT REVERE.

TO MAKE HEAVY-DUTY COPPER

Gaskets

USE REVERE DEOXIDIZED

Tube!



Diesel Fuel Injection Pump, made by American Bosch Corp., Springfield, Mass., and gaskets made by cutting rings off 2" deoxidized copper tube.

• An important extra service rendered by Revere consists of collaboration in setting up specifications. This is valuable because there are many different Revere Metals, each with special characteristics. No one copper, for example, will serve to best advantage in every application. A case in point is the matter of copper gaskets for Diesel fuel injection pumps. Copper is of course an ideal metal for gaskets, and is widely used for that purpose. But for this special application, which copper and in what form? The pump is used on large engines for municipal generating plants. It weighs 186 pounds, and must produce the high pressure required to inject fuel near the top of the Diesel compression stroke. Naturally, the load is a pulsating one. American Bosch Corporation came to Revere with the problem. Our suggestion was that much scrap could be saved if the gaskets were made by cutting rings off copper tube, instead of stamping them from strip. This achieved a double purpose, since the tube is made of deoxidized copper, which is superior in this application to electrolytic. We are able to report that these recommendations proved successful.... This work was done by the Revere Technical Advisory Service. To get in touch with it, see the nearest Revere Sales Office.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

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Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.— Sales Offices in Principal Cities, Distributors Everywhere.

Product Engineering

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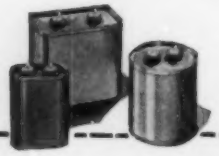
For long life on appliance motors—

choose MALLORY Starting Capacitors



Mallory Motor Running Capacitors help reduce your costs

A new type of internal construction now makes it possible for Mallory to offer motor running capacitors in popular ratings at substantially decreased price . . . and at the same high standards of quality and performance. Impregnated with Mallotrol A*, these compact units are rated for continuous duty up to 75° C.

New combination units, comprising a starting capacitor (for a compressor) and a running capacitor (for a fan motor), give the advantages of smaller size and lower price than two individual units.

**Trade mark*

On the new air conditioners, refrigerators and other motor-driven appliances you are designing, plan to take advantage of the extra values that Mallory Motor Starting Capacitors offer.

Closer capacity tolerances . . . achieved by exclusive Mallory manufacturing methods . . . assure you that every capacitor gives the maximum starting torque and uniform cut-out timing for your specific motor.

Longer service. Series wound construction used in Mallory ratings over 165 volts reduces dielectric stresses . . . gives longer life at high voltage. Mallory capacitors are built to last longer at elevated temperatures.

Thorough humidity protection. Rugged plastic case eliminates the possibility of moisture damage.

Simplified mounting. New spring steel bracket speeds assembly . . . prevents rattling in service, either on or off the motor.

Mallory research has continually made these capacitors more dependable in operation . . . more compact in size . . . more economical in price. Write or call Mallory today for complete data.

Expect more . . . Get more from **P.R. MALLORY & CO. Inc. MALLORY**

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
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P.R. MALLORY & CO. Inc.
MALLORY
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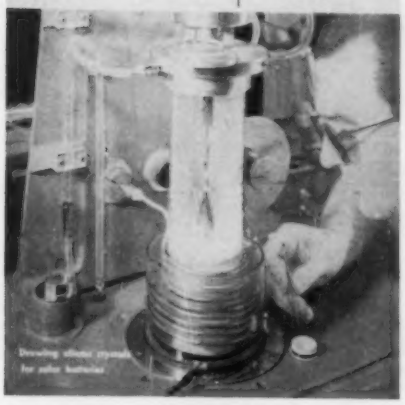
Product Engineering

JANUARY 1955

Science and Engineering—today and tomorrow



THIS MONTH'S COVER

Single crystals of silicon—from which elements are cut for solar batteries—are "grown" at Bell Laboratories in this special furnace. Starting with a seed crystal rotating in contact with a molten pool of silicon, progressive solidification of a single crystal takes place as the rod is withdrawn.

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Highlights

Current research and developments soon to influence product designs.

METALLIC MATERIALS

....Large single crystals of pure germanium can be made for transistors by a new process developed for the Bell Telephone Laboratories, Inc., 463 West Street, New York, N. Y., and described by U. S. Patent No. 2,679,080. Two thimble sized ingots of germanium are melted in an electric oven under a flow of helium. The molten metal is held at 1,800 F for 5 hr and then allowed to cool. One ingot cools before the other and thus gives off enough heat to slow up the solidification of the second ingot so that a large single crystal is obtained. See Science and Engineering section on electricity starting on page 163.

RUST-RESISTING COATING . . . .

....that can be soldered and is inexpensive is a development of the Sylvania Electric Products Physics Laboratory, 20-21 Francis Lewis Blvd., Bayside, N. Y. The coating—called zincaloy—has the corrosion protection of zinc and the solderability of tin or cadmium. The bath used combines tin and zinc plating solution.

HYDROGEN EMBRITTLEMENT . . . .

....of a titanium alloy—3 per cent Mn, 1 per cent Fe, V and Mo—shows that its ductility is adversely affected by absorbed hydrogen. Wright Air Development Center, Wright Field, Ohio, reports that the alloy tested had various amounts of hydrogen ranging from 30 to 300 parts per million. At testing speeds of 0.005 in. per min the reduction of area was decreased when the hydrogen content was 120, 200 or 300 ppm. At room temperature hydrogen up to 120 ppm had little effect at a test speed of 0.05 in. per min. At 200 F the hydrogen could be increased to 200 ppm. At 0.5 in. per min test speed no adverse effect was noted until hydrogen content reached 300 ppm.

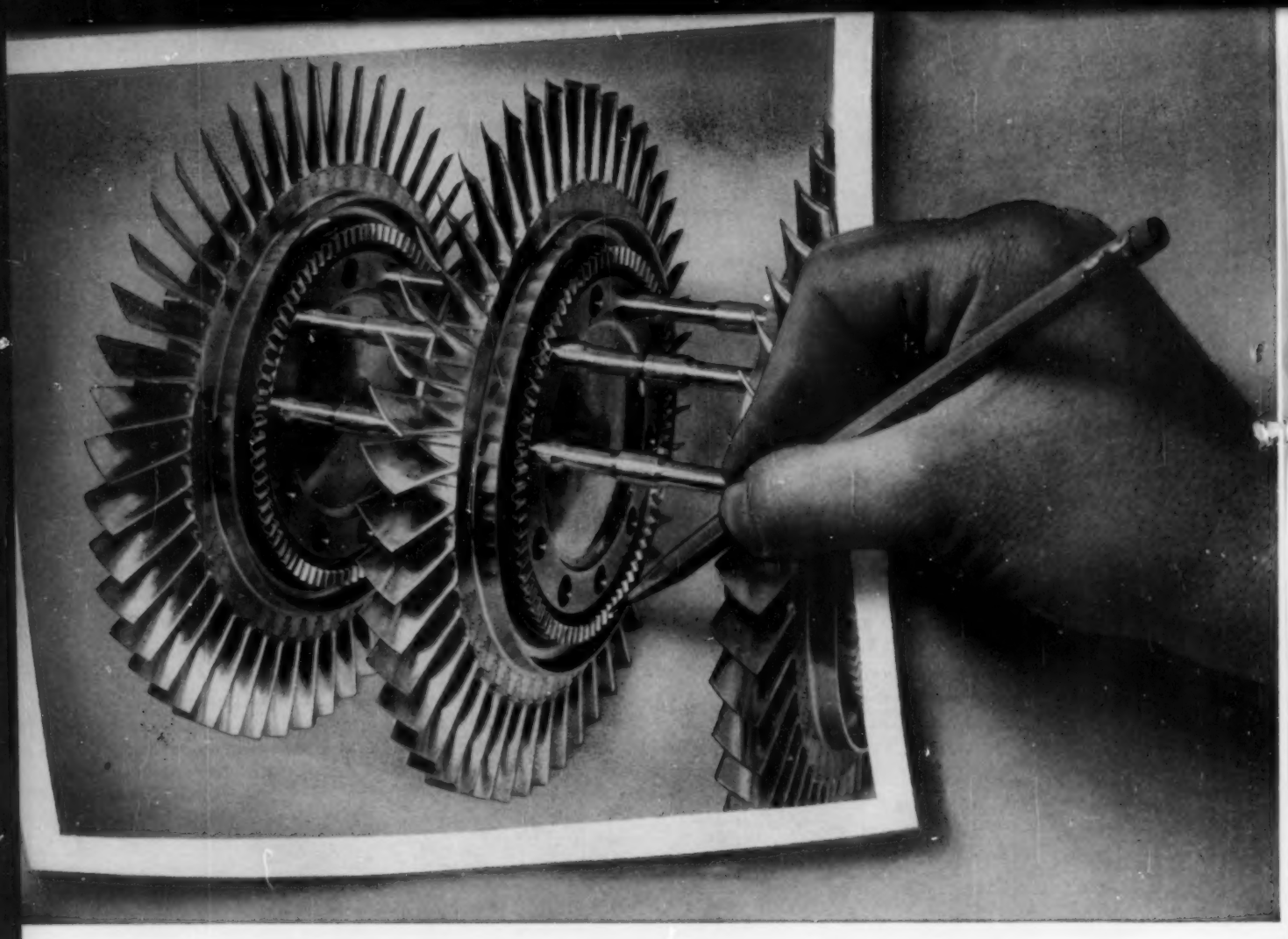
ALUMINUM FOIL . . . .

....can be substituted for fine copper wire when a new method for winding transformer and radio-frequency coils is used. Sylvania Electric Products, Inc., Ipswich, Mass., states that the aluminum foil is either coated with an adhesive insulator or separated with an insulating spacer. This is wound in a roll. Wafers of proper lengths are cutoff of the rolls and used as the transformer winding. Method is cheaper where 44 gage and finer wire is required.

STAINLESS STEEL . . . .

....with improved ductility and impact strength at low temperatures is a development of the Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa. Chromium, nickel and molybdenum are combined with a low-carbon steel base. After forming the metal is chilled to a point below zero. Application, at present, is for airframe construction.

(continued on page 7)



Can CURVIC® Couplings lower the cost of your product?

They have done so for scores of manufacturers, by reducing machining time, by saving time in assembly and by permitting more compact design.

CURVIC Couplings are extremely accurate toothed connections which combine the functions of driving, centering and alignment.

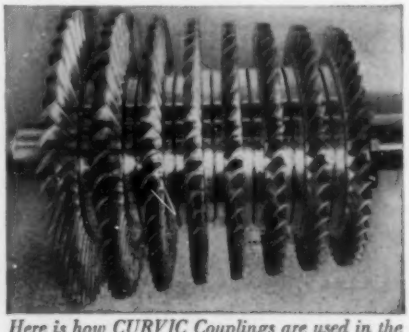
With CURVIC Couplings, complex machine parts can be made in several smaller units and then bolted or otherwise fastened together. Experience has proved that fabrication of many large parts in smaller units has reduced the time spent in machining, simplified final assembly, and reduced over-all manufacturing costs.

And there is no sacrifice of precision —in fact, CURVIC Couplings are so accurate that tolerances in the finished assembly can be held closer than when the part is made by any other means.

CURVIC Couplings are used in such applications as heavy-duty gas turbine rotors like the one shown above, jet engines, crankshafts and camshafts.

In addition to fixed or permanent connections, CURVIC Couplings can be produced in semiuniversal, and in releasing clutch types.

All types of CURVIC Couplings are produced rapidly, economically, and with high precision, on Gleason Cutting and Grinding Machines. If you would like to know more about CURVIC Coupling design or manufacture, the Gleason Works will be glad to consult with you, and to make recommendations about your specific applications. Write for our booklet.



Here is how CURVIC Couplings are used in the production of an 8-stage heavy-duty gas turbine rotor, holding it in perfect alignment under the severe stresses encountered at high speed.

GLEASON WORKS

Builders of bevel gear machinery for over 85 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Highlights

DIE STEEL . . . .

. . . .for the deep drawing and forming of stainless steel is a development of the Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa. The steel is reported to contain 12 per cent V, 1 per cent Cr, 3.25 per cent C, and 1 percent Mo. It is believed it will perform without galling or pickup and should also have outstanding wear resistance.

NONMETALLIC MATERIALS

. . . .A lighter density plastic foam, which is said to have 2-3 times higher tensile strength than other natural or synthetic foams, is a development of the General Tire and Rubber Co., Akron 9, Ohio. High compression qualities, it is claimed, permits the material to support heavier loads. Hence, thinner slabs should provide the same cushioning as heavier slabs of softer foam. Also: the material has open interconnecting cells which reportedly make it useful as a filter, cleaning sponge or applicator. It is claimed to be a cured material and is produced entirely from manufactured materials by a chemical process.

PLASTICS AND GLASS . . . .

. . . .are being combined that will withstand high temperatures over long periods of time. Naugatuck Chemical Div., United States Rubber Co., 132 Elm St., Naugatuck, Conn. says that the material is formed from glass cloth and 3 different plastic resins. Laminate is claimed to be able to withstand 500 F for 8 days. Applications: for high temperature molds and dies and ducts for hot gases.

DRY NYLON . . . .

. . . .because of its high coefficient of friction, is not a suitable solid lubricant, according to studies made at the Naval Research Laboratory, Washington 25, D. C. on the friction and lubrication of nylon. Also: a satisfactory lubricant—for gears or bearings, for example—is one that will absorb, or form a thin film on the surface of the nylon, without attacking the plastic such as alcohol based oils and grease.

FURFURYL ALCOHOL RESIN . . . .

. . . .can be manufactured by an easier and simpler process for the production of plastic products according to the Armour Research Foundation, Technology Center, Chicago, Ill. Method involves forming a resin intermediate by heating furfuryl alcohol in the presence of an activated alumina. Process requires no strong acid catalyst and thus eliminates the steps of neutralizing, washing and drying the intermediates.

COMPONENTS

. . . .Low tension ignition system is being studied and tested by the Navy Department. Developed by the Smitsvonk Co., Holland, and as reported by the Office of Information, Navy Department, Washington 25, D. C., the system promises lower weight and space requirements in that it uses lighter cables and insulators. Under test the engine functioned while 4 spark plugs were frozen in ice; the system was soaked with a continuous stream of water; and started with the electrodes fouled with grease, and abrasive dirt. Economy of construction, quicker combustion, slower idling and higher top speeds may be attained.

HIGH-VOLTAGE BATTERIES . . . .

. . . .now can be printed on a plastic card to power printed radio circuits. Bjorksten Research Laboratories for Electrochemistry, Inc., Madison, Wis., reports that the printing "ink" contains a metallic powder of any magnetic substance such as iron, cobalt, nickel or salts, oxides and alloys of these metals. After printing, the layer is placed in a magnetic field which aligns the metal particles. Additional layers of different metals are applied over the first. The finished layers which can be printed on any non-conducting surface —even paper—then are connected to yield a battery.

SINTERED PLATES . . . .

. . . .composed of 80 per cent air are being used in a long-life nickel-cadmium battery. Amplex Division, Chrysler Corp., Harper & Mt. Elliott, Detroit 31, Mich., report that the plates are made of carbonyl nickel powder—a high purity nickel. Porosity feature permits a greater surface area and, therefore, a greater current capacity. Battery will operate between plus 165 F and minus 65 F. Unit can be 50 per cent charged in 15 min and completely charged in one hour.

A MONITOR . . . .

. . . .that automatically measures bearing temperature is a development of the Bogue Electric Manufacturing Co., 61 Kentucky Ave., Paterson 3, N. J. The unit will automatically ring a bell and flash a light identifying the exact point when the temperature of a bearing rises above a safe limit. The mechanism uses magnetic amplifiers instead of tubes or transistors.

MULTI-PURPOSE FASTENER . . . .

. . . .which is claimed to form a perfect water-tight and air-tight seal is a development of the Townsend Co., River Road, New Brighton, Pa. The fastener has a

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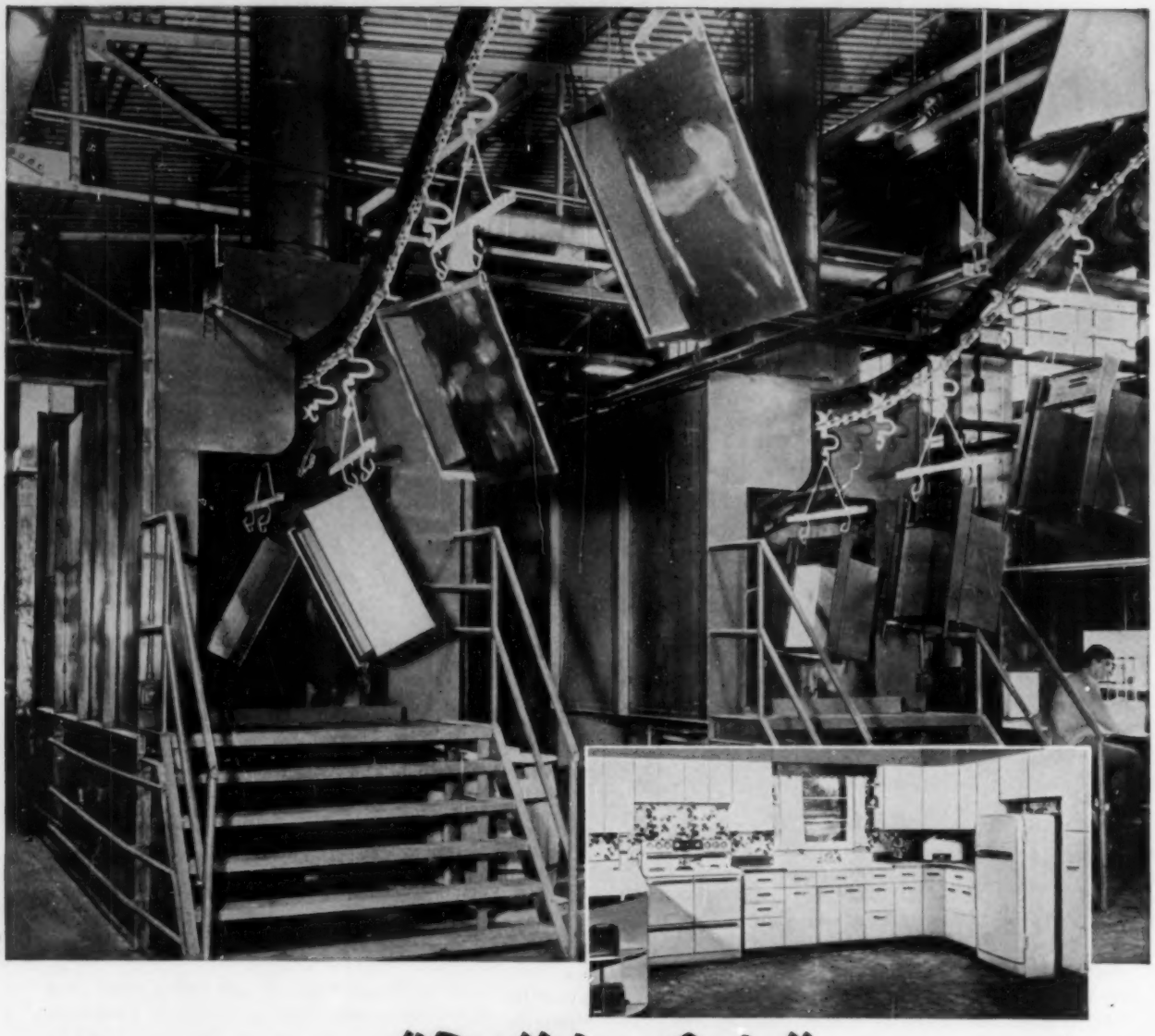

How to get a "Bulldog Grip" on beauty!

The bright, shiny new paint finish looks wonderful when it comes off the production line. Looks equally fine in the showroom, when the customer makes her choice.

Then it gets out into service, and the real test begins.

Bonderite's "bulldog grip" holds paint finish to metal. In Bonderite installations like the one shown above, the surface of the metal (before painting) is converted chemically to a nonmetallic coating integral with the metal which resists corrosion, confines damage from scratches to the site of the injury itself. It's satisfaction insurance, used today on leading painted products of all types where lasting fine appearance is important.

If you aren't now using Bonderite on your painted metal products, better check up and learn how economically you can have its advantages. Call or write today!

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U. S. Pat. Off.*

Since 1915—Leader in the Field

PARKER RUST PROOF COMPANY

2179 E. Milwaukee, Detroit 11, Michigan

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

one-piece metal washer and assembled neoprene washer for use in preventing leaks, for protecting surfaces, and absorbing shock. When seated, an undercut in the washer head traps and controls the flow of the neoprene at the outside edge forming a seal.

LIGHT PULSE GENERATOR . . . .

. . . .a new tool for explosive research—makes possible improved accuracy in detonation, fragmentation and shock wave studies. The Office of Information, Navy Department, Washington 25, D. C., states that the generator is used in conjunction with extremely high speed rotating mirror cameras. This makes possible calibration in intervals of 5 microseconds, thus permitting accurate calibration of the phenomena never before available.

PROCESSES

. . . .Immersion deposited nickel plating for complex, irregular shaped parts seems to be more suitable than the conventional electroplate. Thomson Laboratory, General Electric Co., Lynn, Mass., report that uniform deposits can be produced on internal and external surfaces. Immersion deposit has a hardness of Rc 45. Heat aging for 1 hr at 750-1,000 F increases the hardness to Rc 65-70. Immersion plating appears to be more resistant to corrosion and wear.

ALUMINUM-SILICON ALLOY . . . .

. . . .can be simultaneously modified and degassed by a process granted British Patent No. 712,900 and assigned to the Harborough Construction Co., Ltd., Harbilt Works, Logan St., Market Harborough, Leicestershire, England. Operation of the process is by the addition of metallic sodium and a halogen degassing agent—particularly chlorine. It is claimed that the chlorine does not destroy the modifying effect of the sodium and that simultaneous degassing results in a better product.

COATING OF COPPER . . . .

. . . .to aluminum or aluminum alloy by an immersion plating technique is described by U. S. Patent No. 2,680,711. A strongly adherent coating of copper is applied by electrically connecting the part to be plated to a piece of iron and dipping into an acid copper sulfate bath. The bath contains a colloid such as gelatin, agar, gum arabic, glue or similar material.

STABILITY OF CAPACITORS . . . .

. . . .which use polystyrene as a dielectric has been increased appreciably by a production technique developed by Condenser Products Co., Division of New Haven Clock and Watch Co., 140 Hamilton St., New Haven, Conn. Technique involves a series of heating and aging cycles which have an effect, it is said, on the stability of the film. Capacitors are now claimed to have a drift of less than 0.1 per cent over a temperature range of from —80 to +75 C. New applications are: standard condensers in decade condenser boxes; as charge storage condensers where self time constants of 5,000 hr or more are required; and in resistance capacitance networks.

TESTING

. . . .The positronium atom which is almost 2,000 times lighter than the hydrogen atom, has been under investigation by the Carnegie Institute of Technology, Pittsburgh, Pa. It has been discovered that positronium whirls itself to death, rotating its electrons about a million times in its infinitesimal lifespan and completely transforming itself into energy in the form of three gamma photons. The atom consists of an electron and a positron rotating about each other. Its weight—on the atomic scale—is close to zero.

LIGHTWEIGHT FUEL . . . .

. . . .development for automobiles may be the answer to the smog problem in many large cities. Many experts, according to U.C.L.A., Los Angeles, Calif., consider it impractical to remove smog-producing chemicals from exhaust gases. However, the removal of the heavier components—molecular weights of 150-200—from motor fuels may help. If motor fuel could be changed to lighter compounds—molecular weights of 50-55—such as found in butane and propane, the problem might be solved.

FLAME HEAT . . . .

. . . .or how hot is a flame—is being investigated by the Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa. It is claimed that company engineers have found a way to produce flame in the shape of a flat disk. It is expected to help work out research problems on characteristics of flame in such places as jet engine and gas turbine power plants.

ALUMINUM 26 . . . .

. . . .a long-lived radioactive isotope of aluminum is a discovery of a group of scientists at the Carnegie Institute of Technology, Pittsburgh, Pa. The isotope is reported to have a half-life of about 1,000,000 yrs. This is the first isotope of aluminum that has a life span suitable for tracer experiments. Previous isotopes of Al had life spans of only a few minutes.

These 25 parts of Armco ALUMINIZED STEEL are used by one company in eight different appliances. They are electric toasters, irons, corn poppers, coffee makers, waffle irons, sandwich grills, deep-fat fryers and percolators. Parts include element pans, bottoms, baffles, handle and terminal brackets, crumb tray, shield and base plate.

Special Armco Steel CUTS COSTS OF 25 PARTS FOR MANUFACTURER

Here's what the manufacturer of electrical appliances gained by changing interior parts of eight products from plated metal to Armco ALUMINIZED STEEL:

LOWER COSTS

Elimination of plating ended handling, cleaning and racking costs as well as actual plating costs. This produced savings of as much as 10 cents a part.

BETTER PRODUCTS TOO

Efficiency of all appliances was improved noticeably. The high *heat-reflectivity* of Armco ALUMINIZED STEEL keeps heat inside where it belongs. This makes appliances easier on kilowatts, means lower table-top temperatures.

IMPROVED APPEARANCE

Many of these internal parts are partly visible. When made of plated steel they showed ugly discoloration from high temperatures. The Armco ALUMINIZED STEEL parts show no discoloration because of their fine *heat resistance*.

SEE FOR YOURSELF

If you make products or parts that require a combination of heat – and corrosion-resistance or heat reflectivity, investigate this hot-dip aluminum coated steel. It is made in sheets and coils 13-through 28-gage and in widths up to 48 inches depending on gage. For further information write us for the booklet, "Armco ALUMINIZED STEEL."

ARMCO STEEL CORPORATION
785 CURTIS STREET, MIDDLETOWN, OHIO

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SHEFFIELD STEEL • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

GET G.S. TECHNICAL DATA *Free!*

See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant views, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!

Are You HAUNTED by Excessive Rejects?

SPECIFY G.S. GEARING . .

Even if the horrid reject spectre isn't breathing hot down your back, you'll relax *more*, with G.S. GEARING! For, it's *everlasting* G.S. *accuracy* that counts. One part or a million . . every detail testing to a degree of uniformity long considered impossible in the mass production of Small Gearing. ★ GEAR SPECIALTIES is *everything* this name implies . . SPECIALISTS . . a big, fast-growing organization, with men, methods and machines, developed over 38 years, devoted to making *much better* Small Gearing exclusively! Will you join with us now, in a business relationship which is sure to grow more valuable to you with each succeeding year? Abandon your Small Gear problems on our doorstep. They'll never haunt you again!

FRACTIONAL HORSEPOWER GEARING

GS

GEAR

Specialties, Inc.

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SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING

A SCENE FROM A NEW FILM —SEE IT SOON!

DIE CASTING

RUSH

HOW ELSE WOULD YOU MAKE IT?

Learn what ZINC Die Castings can do for you...

Every design and production engineer should see the new motion picture "DIE CASTING—How Else Would You Make It?" as soon as possible. Produced by the American Zinc Institute, Inc., this brand-new film not only establishes the relationship of die casting to other high speed production methods but it presents the place of zinc among the die casting metals.

Included in the new 35-minute picture are all phases of the die casting process—part design, die design, casting, machining, finishing, and the fields of application. The above picture, for example, is one from a sequence dramatically describing the casting of the 5-foot, one piece Packard radiator grille frame and explaining why it is ZINC. Even though you are now using die castings in the assembly of your products, the film will help you to re-evaluate the die casting process in the light of the latest improvements in this constantly developing industry.

HOW TO SEE THE NEW FILM—
If you have access to projection equipment (the film is 16 mm. Kodachrome with sound) and can arrange to get a group together to see the picture, a print can be borrowed free of charge from the American Zinc Institute, Inc., 60 East 42nd Street, New York 17, New York. When writing, try to give several alternate dates for the showing and advise the size of the audience (you will also receive copies of a new 24-page booklet on die castings for those viewing the film).

The New Jersey Zinc Company
160 Front St., New York 38, N. Y.

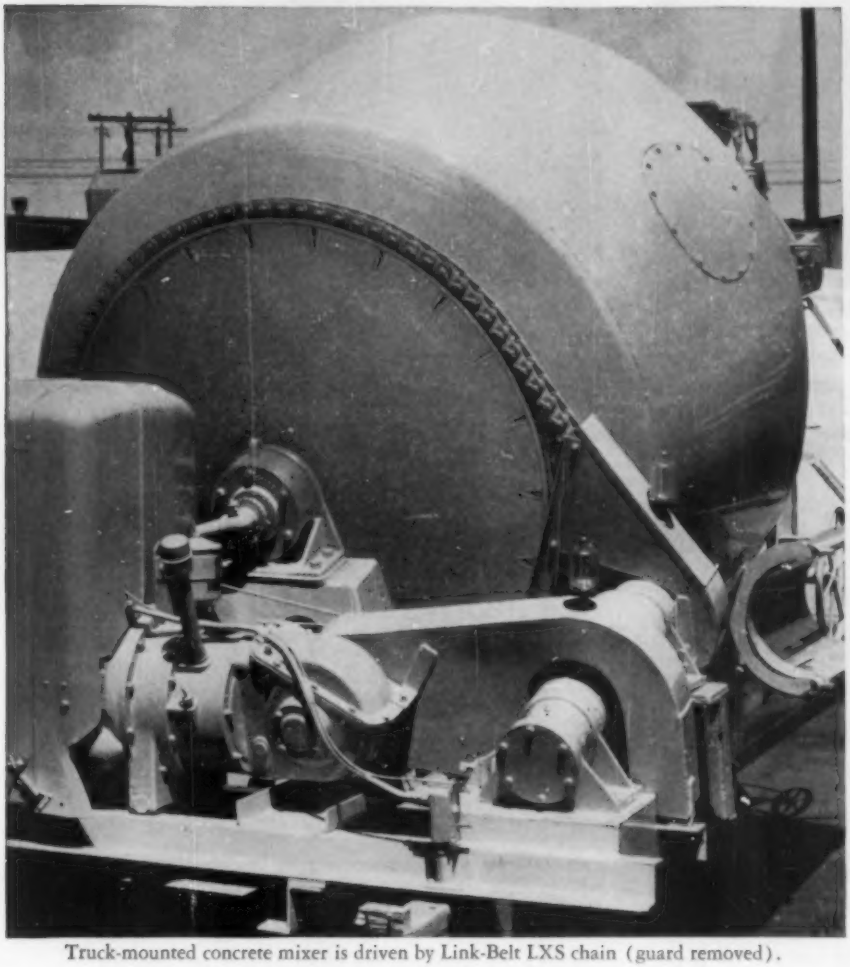
ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

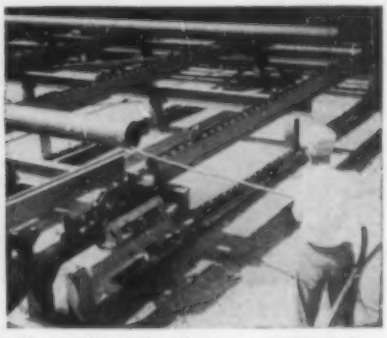
Leading design engineers choose this

Chain for severe conditions

...it's LINK-BELT LXS for drives and conveyors



Truck-mounted concrete mixer is driven by Link-Belt LXS chain (guard removed).



Pipe mill cooling beds use LXS chain with attachments to move heavy pipe smoothly.

Advance-design shovel-crane gets its traveling and steering power through LXS chain.

Accurate sizing of full-round pins, bushings and pitch holes of LXS chain assures proper joint clearances and press fits.

No ONE chain serves every purpose--
get the RIGHT one from Link-Belt's *complete* line

FOR long life under severe drive or conveyor service, Link-Belt LXS chain is the choice of more and more leading designers. Here's a fabricated steel roller chain that *combines ruggedness with accuracy,* thanks to the manufacturing refinements that are a by-word at Link-Belt.

It's the same story for every drive and conveyor requirement — you'll find the chain that's *best* for the job in the complete Link-Belt line. No other single source can equal Link-Belt's broad range of roller and silent chain . . . of cast, combination, forged and fabricated types.

Your nearby Link-Belt office can give you all the facts. Why not call today for an expert, unbiased appraisal of your needs?

LINK-BELT

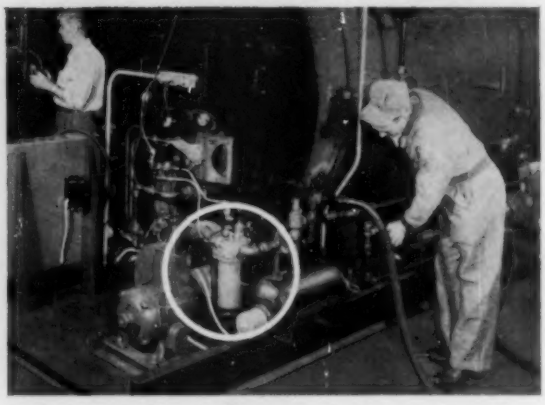
13,804

CHAINS & SPROCKETS

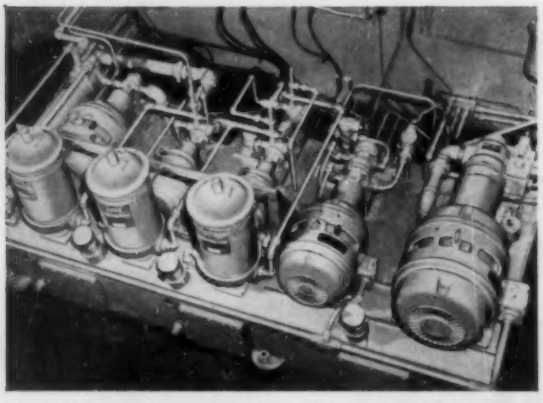
LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

If you can pump it – Cuno can filter it

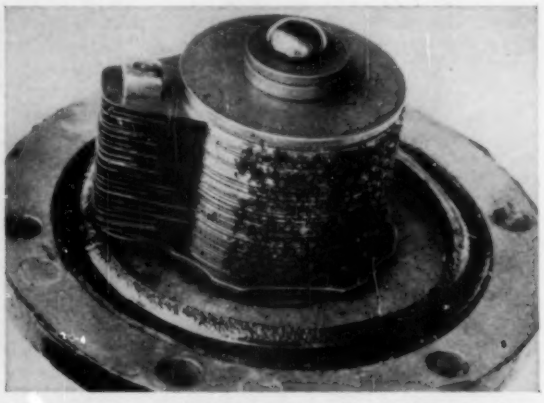
POWERFUL LeTOURNEAU-WESTINGHOUSE Tournapulls, equipped with Cuno MICRO-KLEAN 2-element lube oil filters, work efficiently in areas inaccessible to other earthmovers. When they've got a tough filtration problem, leading manufacturers like LeTourneau-Westinghouse know they can depend on Cuno for the right answer.



FUEL OIL. Leading boiler manufacturer uses continuously cleanable, all-metal Cuno AUTO-KLEANS to filter #6 and #7 fuel oil. He says, "... filter results are very satisfactory. Maintenance of filter is at the minimum." AUTO-KLEANS come in steel, brass or stainless; capacities range all the way from 1 GPM to 3,760 GPM.



HYDRAULIC FLUID. 50-micron Cuno MICRO-KLEAN filters protect precision parts in hydraulic and lube systems of way bed and worm drive box on this horizontal broach. MICRO-KLEAN provides full-flow filtration and protects cylinder rams, liners, valves and other parts.



LUBE OIL. Specially designed AUTO-KLEAN filter after green run in the lubrication system of automotive-type gasoline engine in military service. Note the core sand, sealing paint, lint and metal chips accumulated after only a few hours' operation — graphic proof of the need for full-flow filtration here.

10.4.16

CUNO **ENGINEERED FILTRATION**

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (disc-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound)

CUNO ENGINEERING CORPORATION
DEPT. 3016 SOUTH VINE STREET MERIDEN, CONN.

I'm interested in effective filtration of fuel oil ☐
lube oil ☐ water ☐ coolant ☐ hydraulic fluid ☐
_____.
(other fluid)
Please send me your Filtration Analysis Form ☐
Bulletin ☐

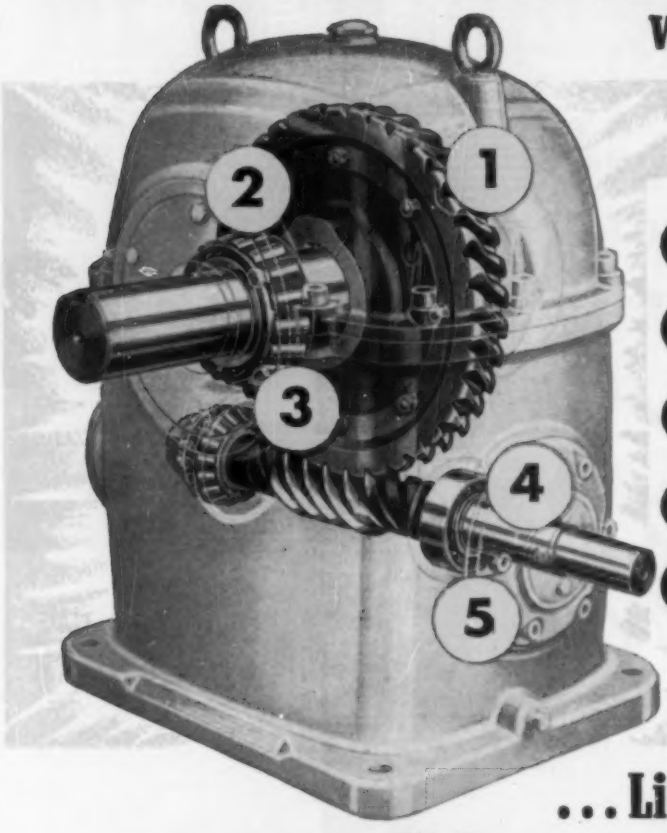
NAME_____

COMPANY_____

ADDRESS_____

CITY_____ZONE_____STATE_____

When your speed reduction job calls for high ratios with right-angle takeoff . . .



1. **NICKEL-BRONZE WORM GEARS,** chill cast in dry sand, combine low coefficient of friction with high tensile strength.
2. **HIGH-CAPACITY ROLLER BEARINGS** take both thrust and radial loads. Lower wear and friction losses reduce maintenance.
3. **ALL-SPEED EFFICIENCY** results from reduced sliding action between worm threads and gear teeth, plus smoother power delivery.
4. **ONE-PIECE FORGED SHAFTS** are alloy steel, carburized and heat-treated for great impact resistance.
5. **AUTOMATIC SPLASH LUBRICATION** reliably supplies oil to all bearings and gear teeth at all speeds.

. . . Link-Belt gives you

everything you want in WORM GEAR DRIVES

WITH their compact, high-strength design, Link-Belt Worm Gear Drives permit high-ratio speed reductions in small space. High input speeds and low output speeds are provided, with ample capacity for heavy loads.

Three basic types cover the complete field of application: Single worm gear drives, helical worm gear drives and double worm gear drives. All are available with either horizontal or vertical shafts, and single or double gear reductions for convenient and compact connection.

Link-Belt Worm Gear Drives are available in ratios to 8000:1, to over 100 hp and 124,000 pound inches torque. For all the facts, contact your nearest Link-Belt office or authorized stock carrying distributor.

Ask for a copy of Book 2324-A, containing selection, rating and dimensional data on Link-Belt Worm Gear Drives.

Get the RIGHT drive combination from LINK-BELT's complete line

In addition to worm, parallel shaft and in-line shaft gear drives, Link-Belt builds variable speed drives, fluid drives—chains, sprockets, couplings, bearings, shafting, etc. All are pre-engineered for easy installation and maximum efficiency.

LINK-BELT

ENCLOSED GEAR DRIVES

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

18,707

weave... wire... mesh... metal...

to your specifications

Precision processed—from weave to wire, mesh to metal, ductility to durability—to your exact specifications—Reynolds Wire Cloth meets the special needs of your products. Details in *Sweet's Product Design File*... or consult Reynolds Engineers.

Reynolds WIRE CLOTH for Ind

REYNOLDS WIRE DIVISION, NATIONAL-STANDARD CO., Box 200, **DIXON, ILL.**

Divisions of National-Standard Co.

ATHENIA STEEL	*Clifton, N. J.* — Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD	*Niles, Mich.* — Tire Wire, Fabricated Braids and Tape
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NEW ATOMIC CANNON

Added Evidence that—

Everyone Can Count on VEEDER-ROOT

This mobile 280 mm. atomic cannon has *two* recoil motions. The primary recoil absorbs the cannon's "kick". The secondary recoil (something new in artillery) absorbs the forces created by the primary recoil. And each recoil motion is recorded by this special Veeder-Root Counter designed with a plunger-action shaft . . . which keeps the score on the cannon's use and indicates approaching need for maintenance.

This again points up the fact that "Anything Worth Making — or Worth Doing — *Is Worth Counting*." And Veeder-Root has the experience and resources *you* can count on, to give you any counter you need . . . for any mechanical or electrical application . . . in any field from Atomics to Automation. Write:

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Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
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"The Name that Counts"

Mechanical

Where moderate speed range is required and where machine may be stopped to make speed changes. Horsepower range—1½ to 300. Speed adjustment range—9 to 28 percent. Two *Vari-Pitch* sheaves used together double range of adjustment.

Combination starter

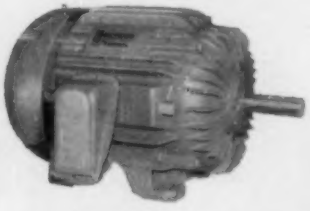
Squirrel-cage motor

Vari-Pitch stationary control drive

Mechanical

Where infrequent change of speed in low horsepower drives is required and machine may be stopped for speed adjustment. Especially suitable for fan drives, stokers, small pumps and tools. Horsepower range—fractional to 4 hp. Speed adjustment range—18 to 50 percent. Use of two adjustable sheaves doubles speed adjustment range.

Across-the-line starter



Squirrel-cage motor

Texrope adjustable drive

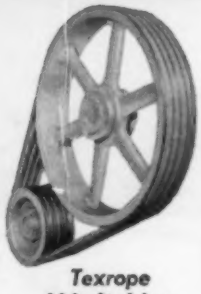
EIGHT WAYS TO GET VARIABLE SPEED

Electrical

Where stepped speed control is satisfactory. Available with stepless control in larger sizes by using liquid rheostat. Speed is varied by means of control on secondary windings of motor. Horsepower range—5 hp and up. Speed adjustment range—50 percent of synchronous speed to full load speed.

Wound-rotor motor control

Wound-rotor motor

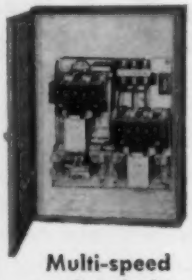


Texrope V-belt drive

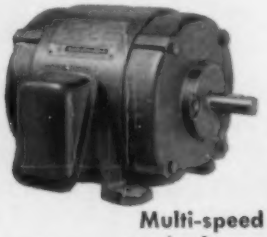
Electrical

Where a few definite speeds are required. Up to four speeds available from one motor. Motor is built on standard squirrel-cage frame with special windings and control. Furnished for variable torque, constant torque and constant horsepower. Horsepower range—½ hp up.

Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.



Multi-speed motor starter



Multi-speed squirrel-cage motor

Texrope V-belt drive

Write for Engineering Literature

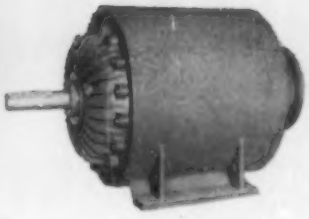
A-C ALLIS CHALMERS

ALLIS-

Mechanical

Where speed must be changed while machine is in motion. Particularly good for machines requiring fine adjustment while operating. Double range of adjustment may be obtained by using two *Vari-Pitch* sheaves. Horsepower range—1½ to 600. Speed adjustment range—9 to 28 percent with one *Vari-Pitch* sheave.

Reduced voltage starter



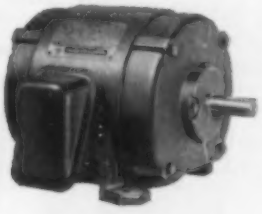
Squirrel-cage motor

Vari-Pitch motion control drive

Mechanical

Where very wide range speed control is required or where enclosed unit is desired. May be manually or remotely controlled. Motor may be mounted on speed changer housing for compact installation. Horsepower range—1½ to 75. Speed adjustment range—3¾ to 1.

Across-the-line starter



Squirrel-cage motor

Vari-Pitch speed changer

COMPLETE DRIVES from One Reliable Source

Electrical

Where great versatility is required. Speed may be varied by various types of control, either stepped or stepless. For both constant and variable torque loads. Horsepower range—½ hp up. Speed adjustment range—zero to maximum speed. Maximum speed in smaller sizes, 3500 rpm.

Direct current control

Direct current motor

Texrope V-belt drive

Combination

Where extremely wide range is required, a combination drive adds the speed control range of the motor to that of the *Vari-Pitch* drive. Hundreds of combinations of any of the above units can be worked out to fit the requirements of a particular design.

Wound-rotor motor control

Wound-rotor motor

Vari-Pitch motion control drive

A4523

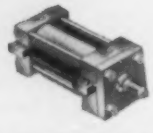
CHALMERS Milwaukee 1, Wisconsin

HANNIFIN SQUARE

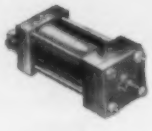
SERIES "A" AIR CYLINDERS

Made in 11 bore sizes from 1½" to 14"...13 standard mountings...many combinations. Extremely close tolerances insure accurate, easy mounting. Steel heads. Cylinders of hard-drawn, high strength brass honed to a satin finish. Piston rods ground and polished then hard chrome plated for extreme smoothness as well as corrosion resistance.

TYPICAL MOUNTING STYLES

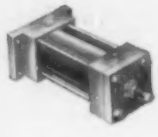


Centerline Lugs

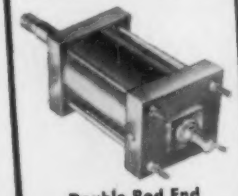


Clevis Mounted

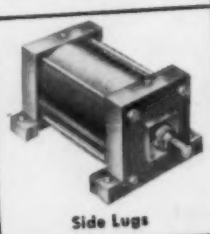
Rod End Flange



Blind End Flange

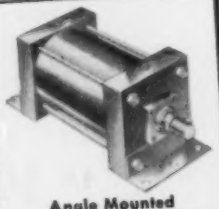


Double Rod End



Side Lugs

Holes in Rod Head



Angle Mounted

WRITE FOR BULLETIN 213

Just off the press. The easiest catalog to use in the cylinder business. Write today.

HANNIFIN AIR CONTROLS

Hannifin has the most complete line of air control valves. Exclusive designs, many types, for hand, foot, cam or solenoid control of air cylinders, presses, and other air-operated equipment. Ask for recommendations.

DISC-TYPE VALVES

Bronze discs lapped to perfect seal with seats. Packless design. For hand, foot or electrical operation.

P-M PILOT-MASTER VALVES

The P-M line provides faster, easier operation for the simplest to the most complicated air-operated circuit. 2-Way, 3-Way and 4-Way Master Valves and Solenoid Pilot-Master Valves...also direct operated 3-Way and 4-Way valves with a wide choice of operating heads.

WRITE FOR CONTROL VALVES CATALOG

The complete air controls catalog! Write for your copy today.

HANNIFIN

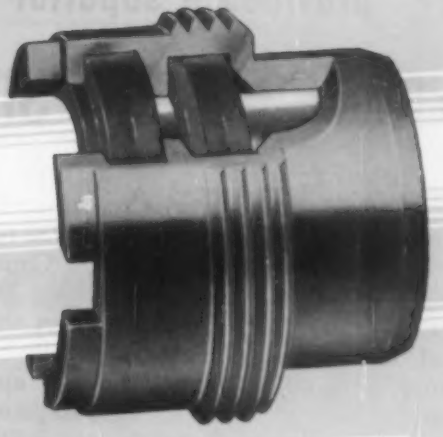
Hannifin Corporation, 525 South Wolf Road, Des Plaines, Illinois

Air and Hydraulic Cylinders • Hydraulic Power Units • Pneumatic and Hydraulic Presses • Air Control Valves

TYPE CYLINDERS

BOTH WITH NEW, CARTRIDGE GLAND

...externally removable and replaceable without dismantling cylinder!

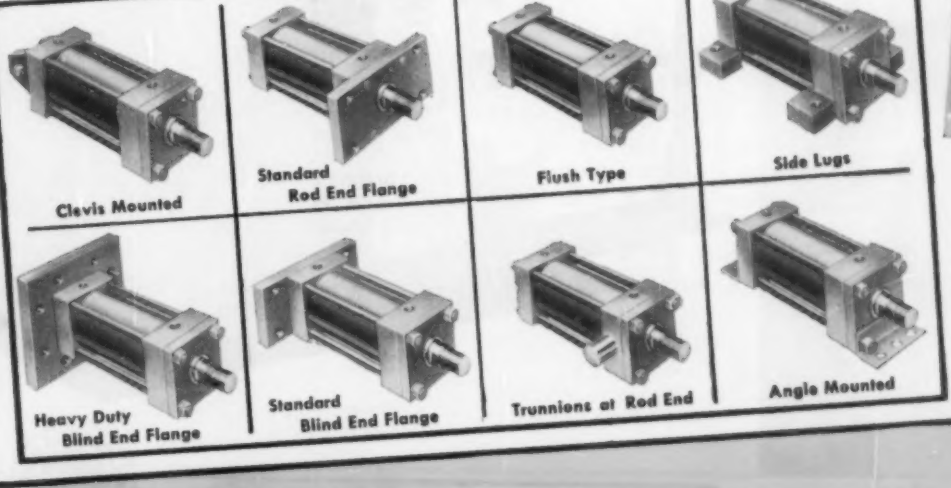


Here's the biggest improvement in cylinder design in the last 50 years. This exclusive Hannifin gland is a bronze cartridge, externally removable and replaceable as a unit to meet J.I.C. recommendations. A face type spanner wrench is the only tool you need. Now look at the packing! The "Wiperseal" serves a dual purpose as it wipes both ways to provide a dry rod on the out-stroke, a dirt-free rod on the in-stroke. The "Lipseal" is self-compensating, self-relieving and non-adjustable... provides an efficient seal throughout its long life. Ask for a demonstration... every Hannifin man carries a cutaway sample of this "jewel" of a gland with him at all times.

SERIES "H" HYDRAULIC CYLINDERS

Made in 9 bore sizes from 1½" to 8"... 13 standard mountings... many combination mountings. Extremely close tolerances for easy mounting. Heavy-duty tie rods. Steel heads. Steel cylinder bodies "Tru-Bored" and honed to a satin finish. Piston rods ground and polished then hard chrome plated for minimum friction and long packing life.

TYPICAL MOUNTING STYLES



WRITE FOR BULLETIN 113

Get your copy of this complete, easy-to-use catalog today. Everything you need to order from is here.

HANNIFIN

Hannifin Corporation, 525 South Wolf Road, Des Plaines, Illinois

Air and Hydraulic Cylinders • Hydraulic Power Units • Pneumatic and Hydraulic Presses • Air Control Valves

Here's How the *Original*

Gilmer "TIMING"®

provides a superior spindle drive, at lower cost, on

NEW BRITAIN'S SINGLE SPINDLE AUTOMATIC

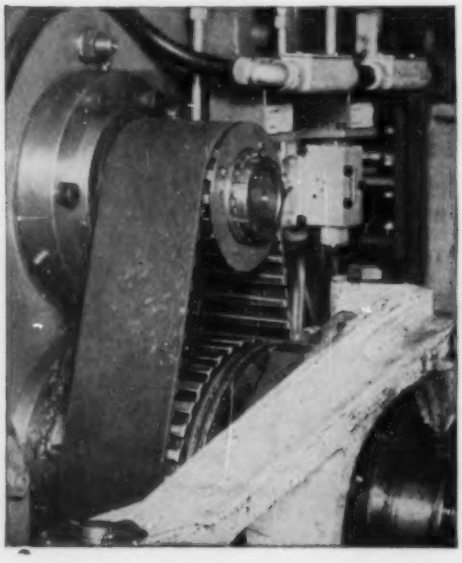
DESIGNERS of some of America's finest machine tools are among the most enthusiastic users of the Gilmer "Timing" Belt Drive. With many, its unique combination of features has made it a "must" on all new model designs!

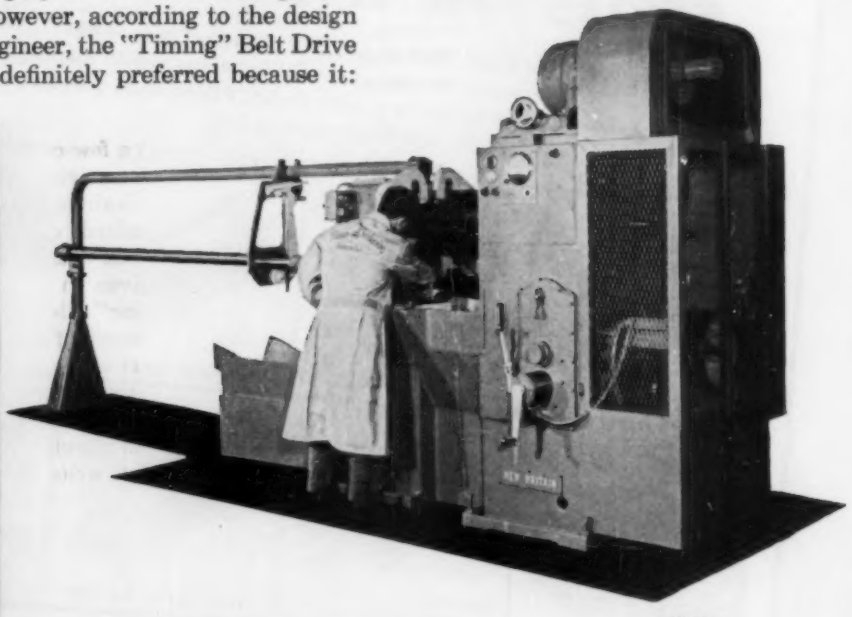
One example is New Britain's Model 126 Single Spindle Automatic Bar Machine. Newest of a proud line of automatic machine tools, its spindle is driven by a 4"-wide "Timing" Belt. Power is provided through a variable speed control by a 15 hp motor at 1750 rpm.

Compactness of the "Timing" Belt Drive is emphasized by the fact that the driving and driven pulleys, mounted on 9⅛" centers, are approximately 4½" and 9" in diameter.

Before the advent of the "Timing" Belt Drive, a train of 3 precision gears would have been employed to drive the spindle. However, according to the design engineer, the "Timing" Belt Drive is definitely preferred because it:

- **Drives the spindle at a constant angular velocity, without slippage or backlash—very important in precision threading operations.**
- **Delivers maximum power to spindle.**
- **Eliminates need for lubricating and housing the drive.**
- **Is quieter, smoother and vibrationless in operation.**
- **All things considered, is least expensive.**

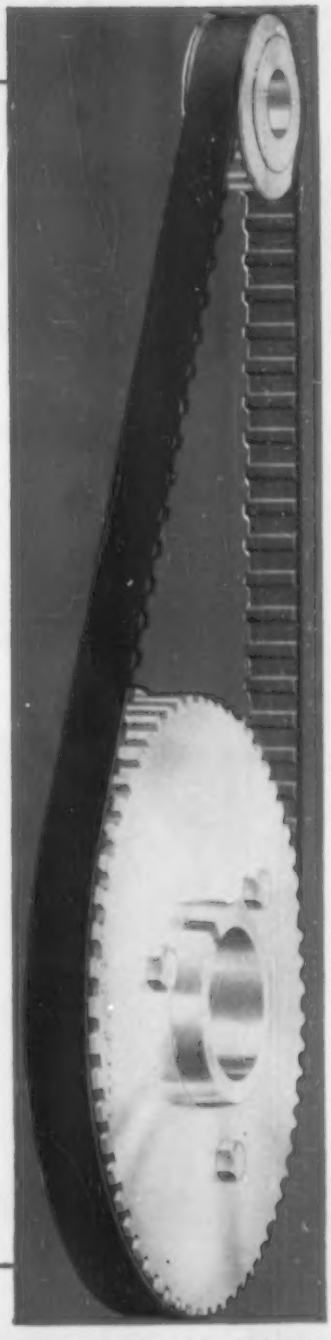




NEW YORK BELTING & PACKING CO. • Founded 1846

NYB & P

BELT DRIVE



Industry's Newest Power-Transmitting Medium

Sweeps away design restrictions

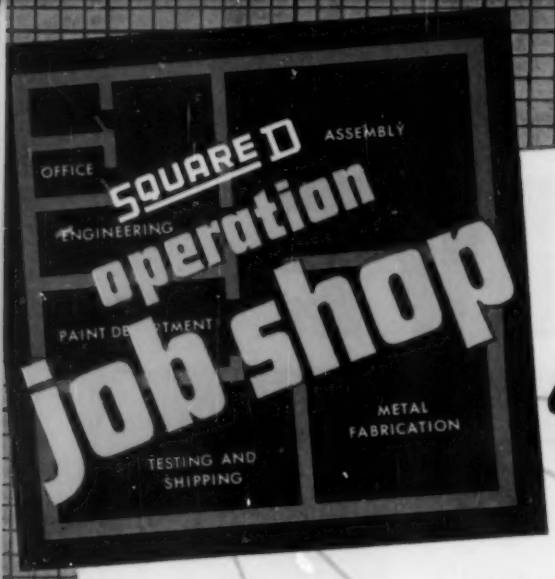
In one application after another, "Timing" Belt Drives have enabled machine designers to achieve basic engineering improvements—or to design entirely new machines—that were previously either impractical or impossible! For never before has there been a *positive drive* that combined all these desirable characteristics:

- **Requires no lubrication, no housings or lubricant guards.**
- **Maintains precise synchronization ("timing") between shafts.**
- **Provides speed ratios as high as 15 to 1 in a single step.**
- **Operates satisfactorily at speeds from inches per hour to 15,000 fpm.**
- **Permits use of very small diameter pulleys for ultra-compact drives.**
- **Has nearly 100% mechanical efficiency.**
- **Needs no initial tension. Lighter bearing loads permit lighter bearings.**
- **Does not stretch or lengthen with use; requires no take-up.**
- **Can be designed for zero backlash.**
- **Capacity ranges from 1/100 to 300 horsepower.**

These are but a few of the unique features of this amazing tooth-grip belt drive that is already in successful use on hundreds of thousands of machines. Full details and description are given in the 76-page Gilmer "Timing" Belt Manual, which lists hundreds of drives available promptly from stock. For your copy, call your nearby Gilmer "Timing" Belt Distributor. Or, if he isn't listed in the classified telephone directory, write to the address below.

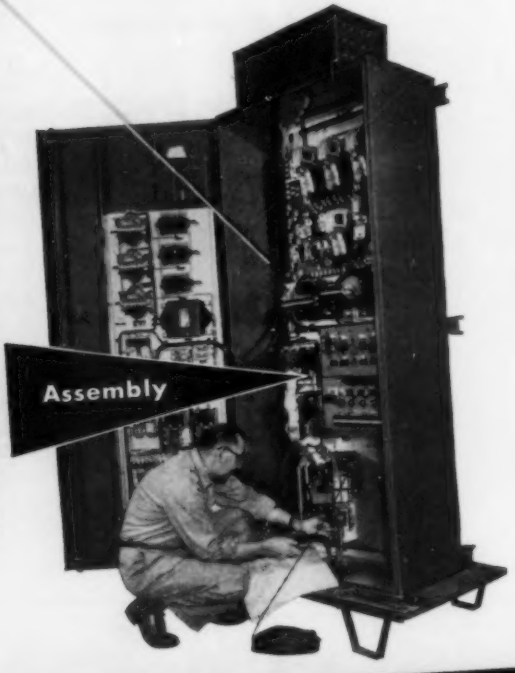
NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products



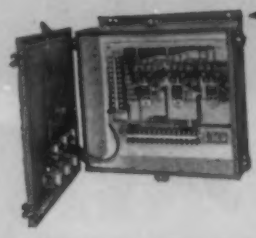
offers you BETTER Custom-built Motor Control

• Square D's latest contribution to design leadership—completely integrated "job shop" operations for design and manufacture of custom-built motor control. These new facilities operate independently of Square D's general manufacturing plants. They utilize the full-time, specialized skills of engineers and craftsmen. They add vital support to Square D Field Engineers in meeting special control needs.

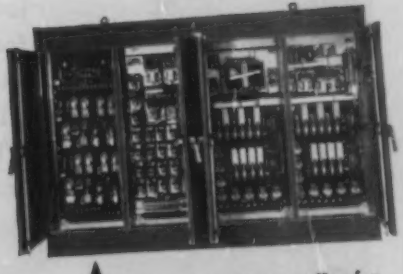


SQUARE D COMPANY

..SIMPLE OR COMPLEX—LARGE OR SMALL



Square D builds special controllers ranging from those requiring only a few simple components *(at left)* to those employing hundreds of inter-connected devices *(below)* for controlling complex machine tools and processes.



A large AC-DC controller for machinery requiring both adjustable and constant speed motors.

Custom-built controllers can be constructed in accordance with NMTBA, IIC, and individual customer specifications. The one at left meets IIC standards.

Engineered, Factory-Assembled and Tested by
SQUARE D COMPANY

This label reflects quality and performance standards which are achieved by a complete integration of engineering, assembling and testing—all under factory control.

SQUARE D COMPANY, Dept. **101**
4041 N. Richards Street, Milwaukee 12, Wis.

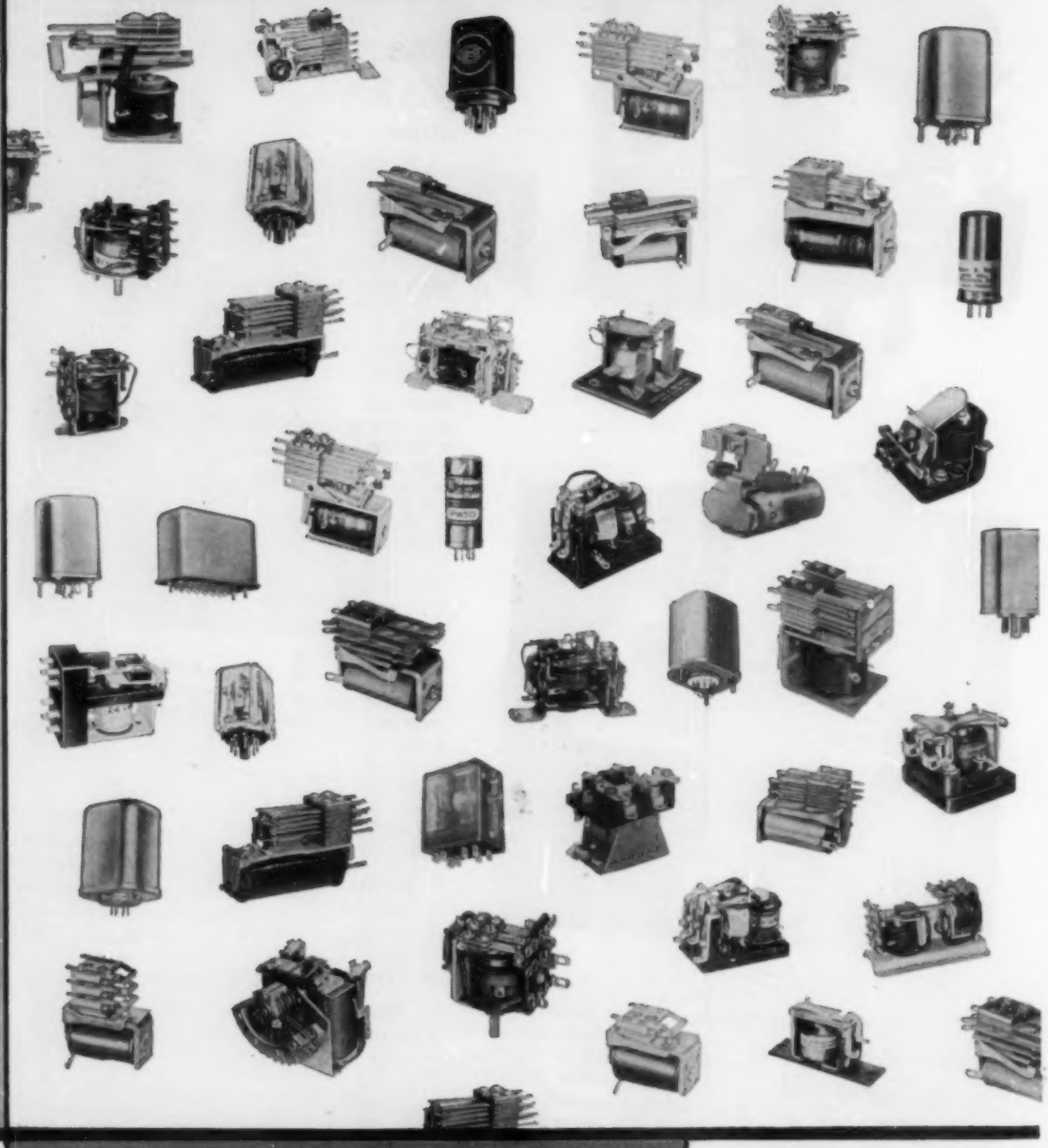
Please send me a copy of your new booklet which gives the complete story of Square D's new **JOB SHOP OPERATION.**

Name _____

Address _____

City _____ Zone _____ State _____

RELAYS by Potter &



. . . all types . . . all sizes
. . . for all applications

Another AMF Product
P&B Relays

Brumfield and Sterling Engineering

now joined as subsidiaries of AMF

AMERICAN MACHINE & FOUNDRY COMPANY

A leader in the design and application of electrical relays for nearly a quarter of a century, Potter & Brumfield combines with Sterling Engineering to provide the finest engineering, production, and testing facilities in the relay industry.

Lower Prices. Our large inventory and wide variety of standard relay components, backed by our increased manufacturing resources, makes it possible for us to fill special needs without added cost. It means operating economy for us—greater savings for you.

Greater Selection. To the extensive line of Potter & Brumfield (over 20,000 combinations and versions), has been added Sterling's wide selection of different relay structures—assuring fast delivery of all but the most highly specialized relay designs. And our new, expanded engineering department is the best equipped in the industry to answer unusual demands for industrial or military applications.

Greater Service. Two outstanding names, each specializing in different relays, now operate under a single greatly expanded research and engineering department. There are sales engineering offices in all principal cities of the United States and Canada, staffed with specialists well versed in relay know-how. Manufacturing facilities in Princeton, Indiana, and Laconia, New Hampshire, for quick deliveries.

Samples of P&B and Sterling relays are available for immediate shipment. Send your specifications for recommendations and quotations. Standard relays are stocked by Electronic Distributors in most cities in the United States and Canada.

Write home office in Princeton, Indiana, or phone your local P&B office for our new Engineering Guide.

Another AMF Product
Sterling
RELAYS

POTTER & BRUMFIELD MFG. CO.
STERLING ENGINEERING CO.
Princeton, Indiana

Wagner®
ELECTRIC MOTORS
...the choice of leaders in industry

Here's why the Wagner Type RK the Right Kind of motor for your

A lot depends on the motor you specify to power your product. The selection of a Wagner Motor will assure:

Customer Acceptance — that results from the recognition of a motor built by a manufacturer with a *proven* reputation for quality motors . . .

Customer Satisfaction — that results from uniform trouble-free performance and long-life operation . . .

Customer Service—possible only when the motor manufacturer has the ability and the organization to provide immediate repair parts and service, *when* and *where* they're needed.

The Wagner Type RK Capacitor-start induction motor meets these requirements and offers the additional advantages shown at the right. That's why the RK is first choice of many leading manufacturers of machines and equipment that require single-phase motors in fractional or integral ratings up through 5 hp.

When you standardize on Wagner Motors—you get the advantages of a liberal warranty . . . of nationwide service facilities, with on-the-spot service, replacement motors and parts available from 25 Wagner-owned Service Branches and more than 850 Authorized Service Stations. You can also choose from a wide variety of types and sizes—single-phase or polyphase—(from 1/125 to 400 hp). Bulletin MU-185 gives complete information—write for your copy.

Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
6406 Plymouth Avenue • St. Louis 14, Mo., U. S. A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 32 PRINCIPAL CITIES

M55-1

NEW 56 FRAME RESILIENT MOUNTING

This Wagner Type RK is shown in the new 56 frame that is used for ⅓, ½ and ¾ hp ratings. The resilient mounting offers unusual freedom from vibration and noise. Smaller fractional ratings, and integral sizes from 1 through 5 hp, are also available.

NEW 56 FRAME WITH WELDED RIGID BASE

Wagner rigid base Type RK motor, in the new 56 frame size. The formed steel base is securely welded to the rolled steel frame to produce a strong, rigid assembly that will not get out of alignment. Type RK is also available with machined end plates for flange mounting.

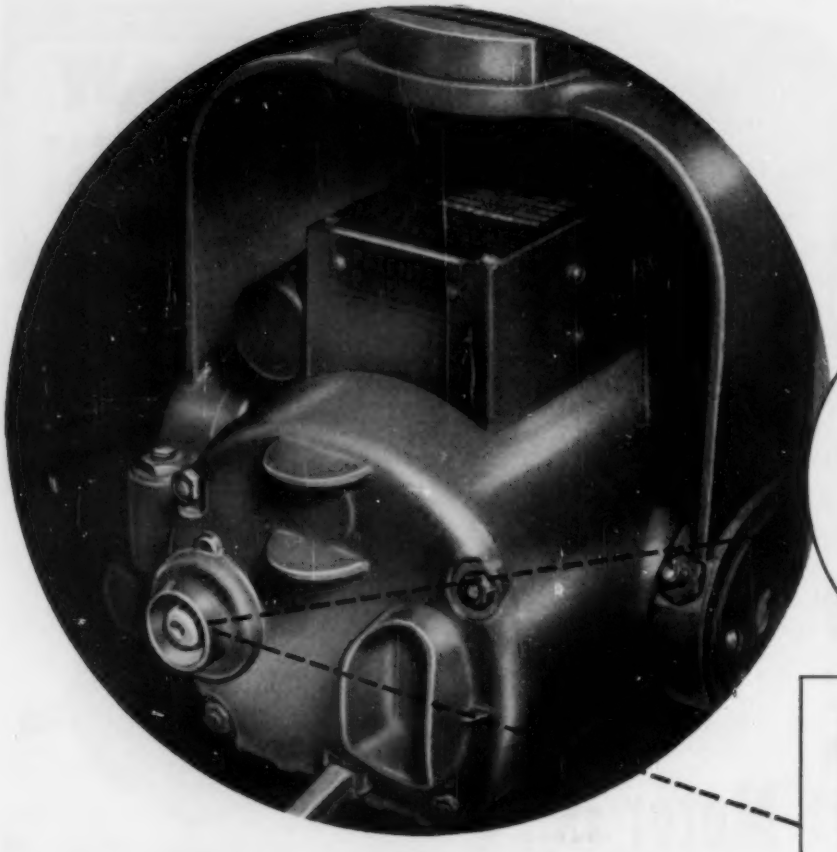
Capacitor-Start Motor is single-phase applications

THICK ROLLED STEEL FRAMES

Frames for these motors are made of thick rolled steel, with machined beads on each end which accurately position the end plates. The frames have no openings, and are treated inside and out to prevent rusting.

LONG-LIFE CENTRIFUGAL SWITCH

These motors are equipped with the Wagner-made quick-break switch that disconnects the starting winding and capacitor from the line when the motor approaches operating speed. It will make over a million starts and stops without trouble — your assurance of years and years of unfailing performance.



KLIXON MANUAL RESET PROTECTOR

KLIXON PROTECTORS *SAFEGUARD*

Motors in DeWalt Woodworking Machines

DeWalt woodworking machines have long been known for their quality and efficiency.

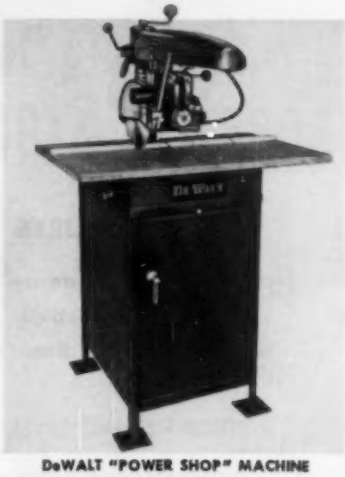
To keep their custom-built electric motors operating dependably and safeguard them against failures through motor burnouts, DeWalt Engineers incorporate a built-in protector in the motors.

Mr. E. W. Forth, Quality Control Manager, states — "The quality of Klixon motor protectors have been good. We use them extensively in a wide variety of sizes and types for single phase motors. They have always proved adequate while at the same time not too expensive."

You, too, can keep motors in your equipment operating dependably by specifying and using Klixon protected motors. The additional cost is low . . . the benefits exceptionally worthwhile.

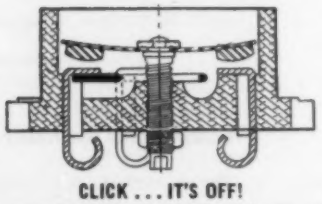
KLIXON

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
901 FOREST STREET, ATTLEBORO, MASS.



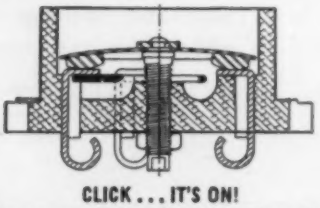
DeWALT "POWER SHOP" MACHINE

HERE'S HOW KLIXON PROTECTORS WORK!



CLICK . . . IT'S OFF!

Should a motor become overheated and dangerously hot, the Klixon Protector snaps the power "off" preventing the motor from burning out.



CLICK . . . IT'S ON!

When the motor cools to safety, the Klixon Protector snaps the power "on" automatically, or by pushing the red button when the manual reset type is used.

ALCUPLATE®

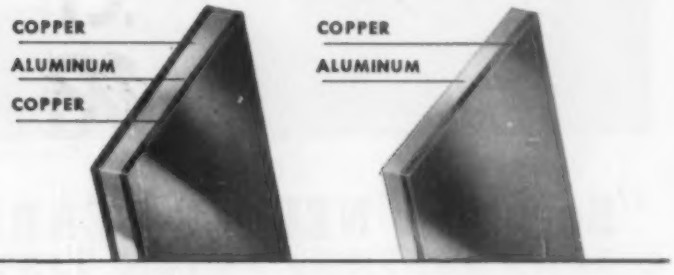
The Material of 1001 USES

Replaces Strip Copper or Brass at Savings up to 30%

Here's the Story:

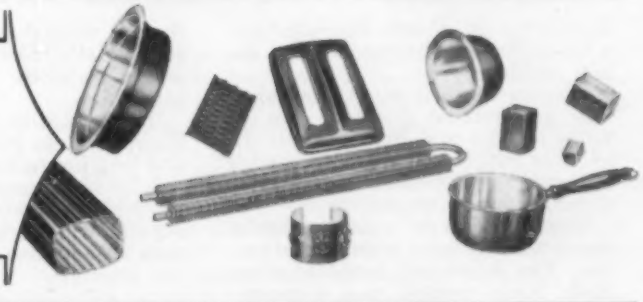
Alcuplate was developed by General Plate to reduce the raw material costs for manufacturers using strip copper or brass.

A composite metal, Alcuplate is a solid layer of copper permanently bonded on one or both sides of less expensive aluminum. This combination has practically the same physical and electrical properties of copper . . . but reduces copper or brass costs by as much as 30%.



ALCUPLATE FEATURES

- Natural copper appearance
- High electrical conductivity
- Excellent heat dissipation
- Soft-soldering surfaces
- Easy fabrication
- Light weight



Here's how ALCUPLATE can be worked:

ALCUPLATE can be fabricated by stamping, drawing, spinning and forming. Its malleability permits its use in the manufacture of many parts from work-hardened rather than annealed or dead soft materials. The copper provides an ideal surface for soft-soldering operations and electroplated or other finishes.

A few typical products where ALCUPLATE is cutting fabrication costs

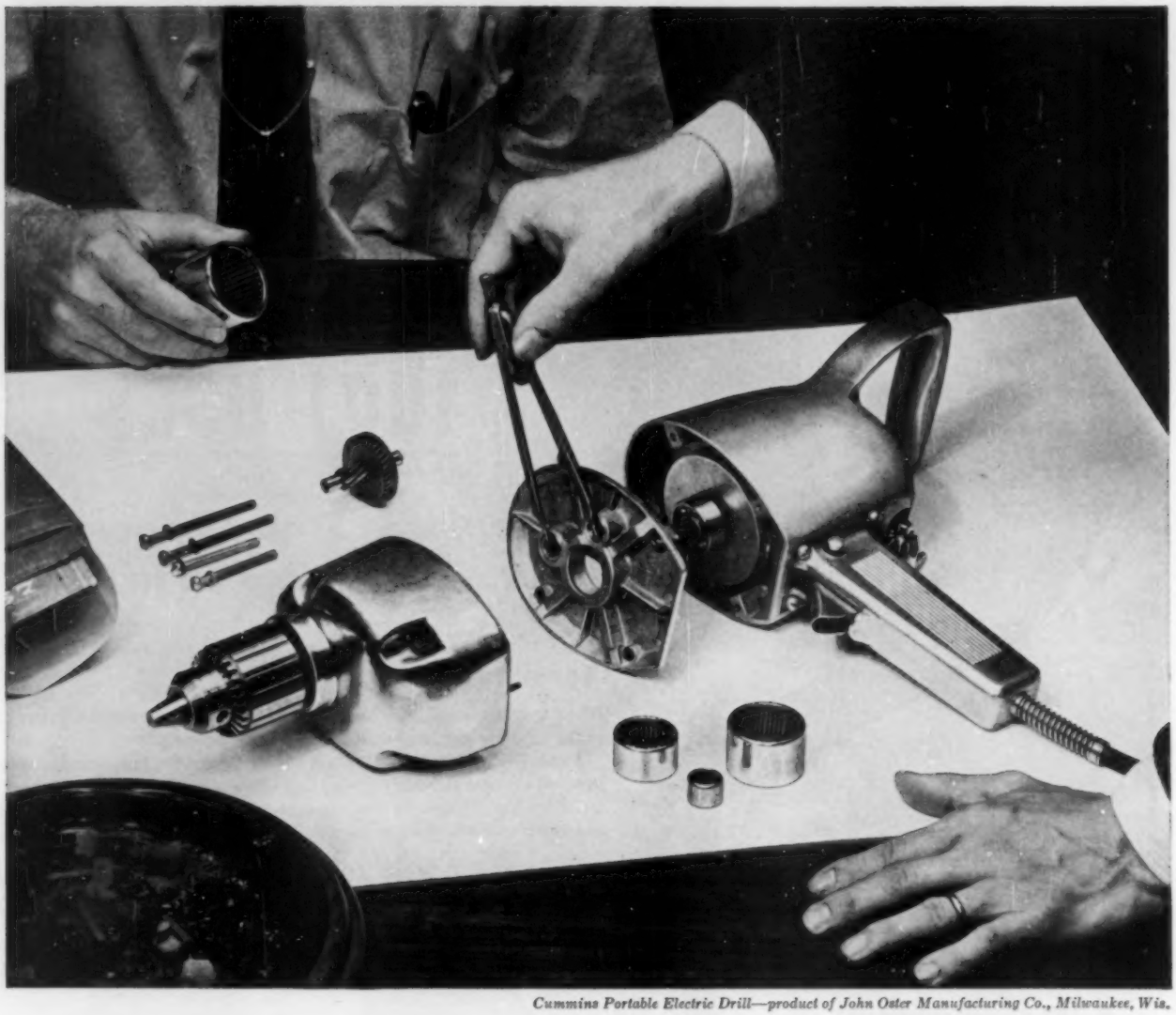
Heat transfer units • Electronic chassis and component cases • Electrical terminals Jewelry • Gift ware • Chafing dishes Water pitchers • Drain spouts

In what Sizes is ALCUPLATE Stock available?

In coils or cut lengths up to 1/16" thick by 13" wide and in a choice of thickness ratios and tempers.

For further information, write or wire

ALCUPLATE®
METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
11 FOREST ST., ATTLEBORO, MASS.



Cummins Portable Electric Drill—product of John Oster Manufacturing Co., Milwaukee, Wis.

"See how NEEDLE BEARINGS Simplify Design"

Torrington DC Needle Bearings have a talent for simplifying complex design problems.

Because of their small size, housings and related members can be made smaller and lighter, shaft diameters can be increased for added strength, and smaller shaft-center distances can be employed.

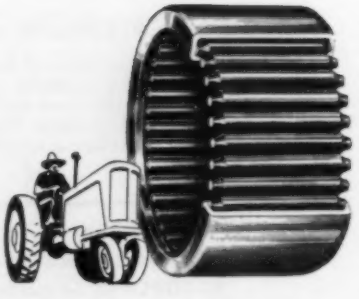
These benefits are a direct result of the Needle Bearing's unit construction. The drawn and hardened outer shell, when pressed into a recommended housing bore, serves as the outer race. A full complement of small-diameter rollers provides many lines of contact for high radial loading. What's more, a hardened shaft serves as a low cost, high quality inner race.

The turned-in lips of the Needle Bearing retain lubricants effectively and help insure long service life.

Why not incorporate these advantages into your product? Our engineering staff will be glad to help you with your anti-friction problems.

• • •

THE TORRINGTON COMPANY
Torrington, Conn. • South Bend 21, Ind.

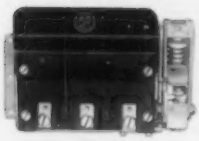


Tractors, harvesters, combines, mowers and many other farm machines produced by leading manufacturers utilize Torrington Needle Bearings to good advantage. In main drives, crankshafts, gearboxes, idler pulleys, steering gears, hydraulic pumps and a host of other assemblies, Needle Bearings take the punishing loads of daily farm use.

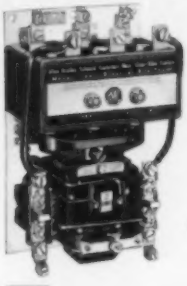
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

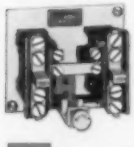
Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers



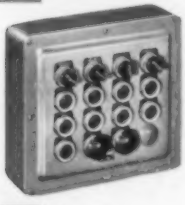
1 **Manual Disconnect** with cabinet door handle safety interlock.



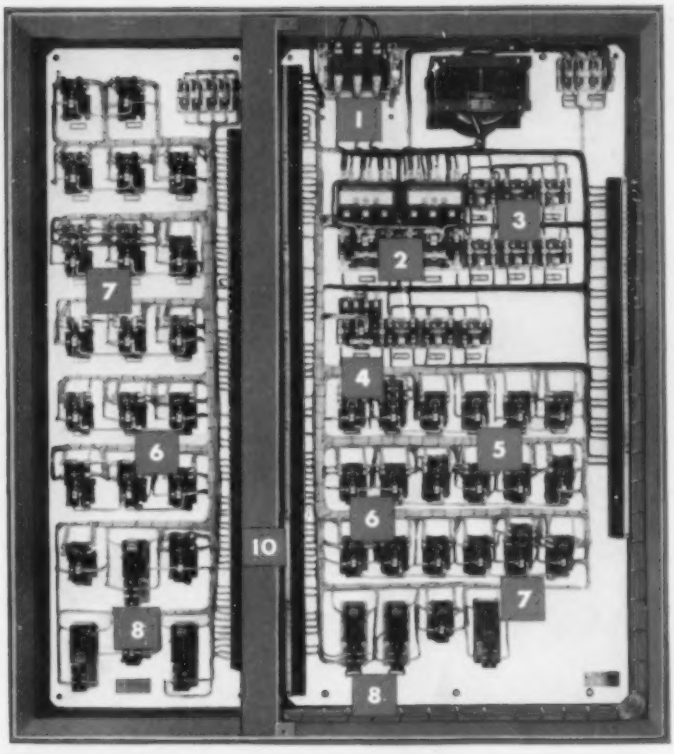
2 **Large Solenoid Starter** with overload relays.



3 **Overload Relays**



11 **Master Station**



10 Automatic Control Panel for Hoern & Dilts boring machine shown below.

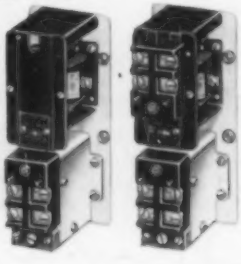
9 **Oiltight Push Buttons**

With mushroom head push button and oiltight diaphragm for oily locations.

With selector for 3-way Automatic-Off-Hand control.

8 **Pneumatic Timers**

Easily adjustable from 1/6 second to 3 minutes. Available in a large variety of On-Delay or Off-Delay contact combinations. Also listed for direct current.



4 **Small Size 1 Solenoid Starter**

Complete line includes 8 sizes—from Sizes 0 to 7.

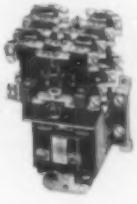
5 **Four-pole Relay**

In any combination of normally open or normally closed contacts.

6 **Universal Relay**

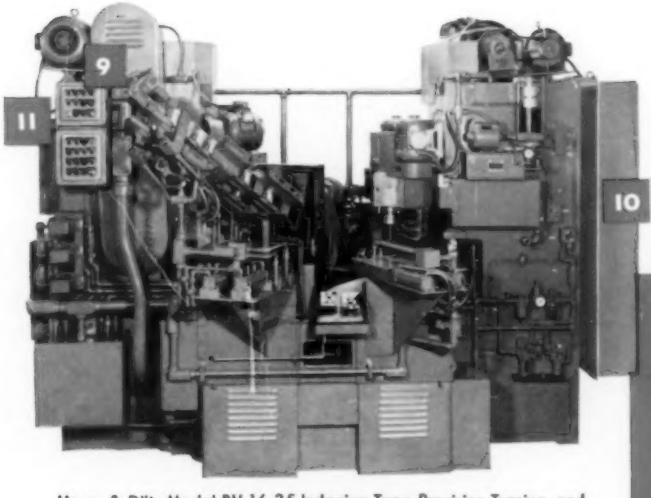
Has normally open and normally closed contacts. Merely change connections.

7 **Eight-pole Relay**



8-Pole relay with 4 N.O. contacts.

How to build trouble-free motor control panels



Hoern & Dilts Model BH-16-35 Indexing Type Precision Turning and Boring Machine equipped with A-B controls and oiltight push buttons.

Special control panels are commonly used with modern production machines. They are the "brains" of the machine—they must be dependable. Therefore, they must be assembled with trouble-free components . . . like the Allen-Bradley starters, relays, timers, and control stations shown on this page. The Allen-Bradley reputation for QUALITY is your assurance of trouble-free operation.

Send for the latest edition of the 120-page Allen-Bradley Handy Catalog . . . it's a veritable handbook of modern automatic and manual motor controls. Write, today.

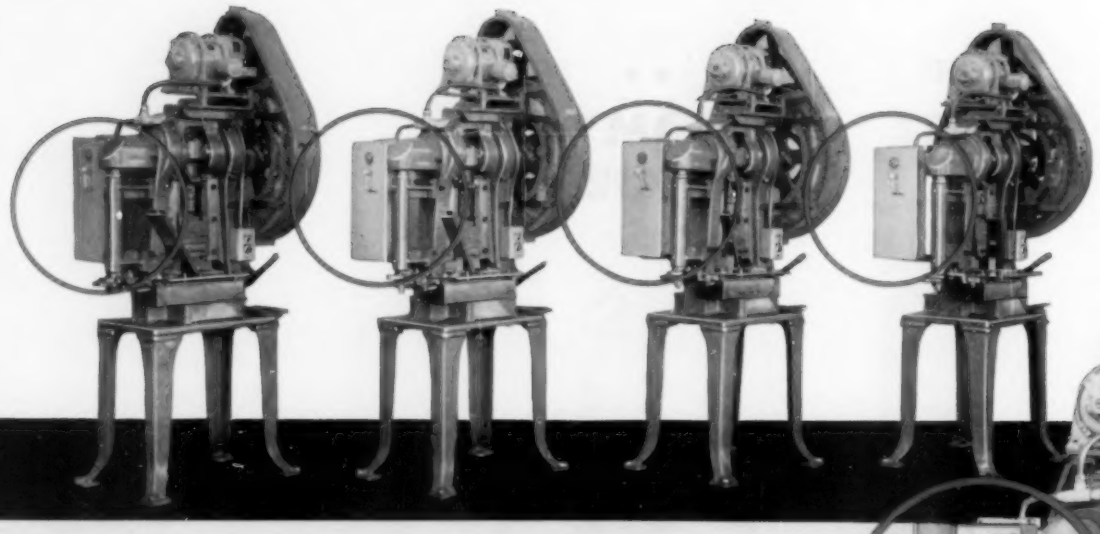
Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.

In Canada—
Allen-Bradley Canada Ltd.
Galt, Ontario

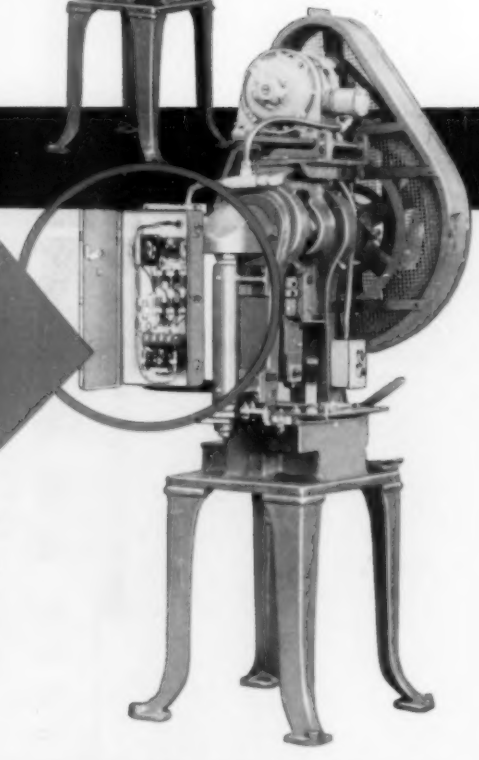
A-B

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

1-55-B



Waterbury Farrel Stamping Presses equipped with A-B Combination Starters.



DISCONNECT SWITCH — FUSES — SOLENOID STARTER
. . . all combined in ONE ENCLOSURE . . .

Alert machinery manufacturers recognize the sales advantage of equipping their motor-driven machines with these compact combination starters. They combine disconnect switch, fuses, and solenoid starter in a single enclosure . . . and they provide this added safety feature . . . it is impossible to open the starter cabinet until the disconnect lever is moved into the OFF position. The combination starter provides a clean, finished appearance—a sales asset for any machine tool. And—the installation cost is less!

Bulletin 712 Combination Starter with Manual Disconnect Switch and Fuses

Bulletin 713 Combination Starter with I-T-E Circuit Breaker

Standardize on A-B COMBINATION STARTERS . . . for Compact and Safe Motor Control

Allen-Bradley combination starters come in two general types—Bulletin 712 with a manually operated disconnect unit (with or without fuse clips)—and Bulletin 713 with an I-T-E instantaneous circuit breaker.

See the neat, compact starter installations on the machines, above. Streamline your machines to give them a "New Look" with Allen-Bradley combination starters. Write, today, for the A-B 120-page Handy Catalog.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

In Canada—Allen-Bradley Canada Limited, Galt, Ont.

ALLEN-BRADLEY

BULLETIN QUALITY 712-713

COMBINATION STARTERS

1-55-R

pointing the way to . . .
GREATER ECONOMY and EFFICIENCY

The Jeffrey Manufacturing Co. makes a continuous mining machine capable of mining 50 to 100 tons of coal per man day, and "Molveyor", a unique train of wheel mounted sectional belts of 15' lengths to convey this high production from the continuous mining machine to the main transportation system — a distance of up to 300 feet or more. A new and safer method of mining coal with greater economy and efficiency.

HEIM *Unibal* ROD ENDS are used in ten locations as circled in the shop picture of the frame of the Molveyor. Here is real punishment for every part on this hard working, heavy duty coal mining equipment. Heim Rod Ends were chosen because they deliver trouble-free performance under even adverse conditions — they correct misalignment in every direction — they are smooth in operation — and they stand up under the heavy loads they are called upon to carry.

You don't make coal mining equipment, you say.

But if, in the operation of your product, you must transmit motion or force at varying angles, there is the spot for a **HEIM *Unibal***. Our catalog has engineering data, specifications, and illustrations. You should have a copy in your files.

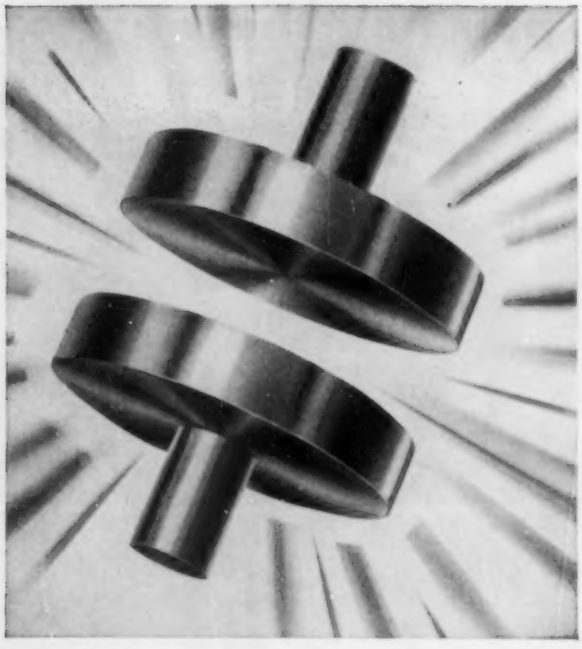
THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

Are the contacts you use

GOOD ENOUGH...

or TOO GOOD ?



The answer to this question can make an important difference in the performance and cost of your product. If your contacts do not measure up to their intended job, they can seriously detract from the satisfactory operation, freedom from maintenance, and acceptance of the equipment in which they are used. If the contacts are too good, or over-designed, they add uselessly to the cost of the finished equipment.

Designing a contact for a specific job, however, is a real engineering problem. It involves consideration of many electrical, mechanical and environmental factors. The current and voltage in the interrupted circuit . . . the type of load . . . the expected service life . . . contact gap . . . contact pressure . . . ambient temperature and atmosphere . . . these and many other aspects of the problem demand evaluation.

From Mallory, you can be *sure* of getting contacts that will perform correctly in your application . . . at a price that fits your production budget.

THE RIGHT MATERIALS. The extensive selection of contact materials developed by Mallory's metallurgical research includes an unequalled variety of specialized materials.

THE RIGHT DESIGN. Mallory engineers apply to your problem the knowledge gained in thirty years of contact experience. Standard designs are recommended wherever possible for standard requirements . . . and for special needs, custom-fitted designs are developed.

THE RIGHT PRICE. Mallory cost-saving design assures top economy consistent with service requirements. Further economies are often realized by having Mallory fabricate your complete contact assemblies for you.

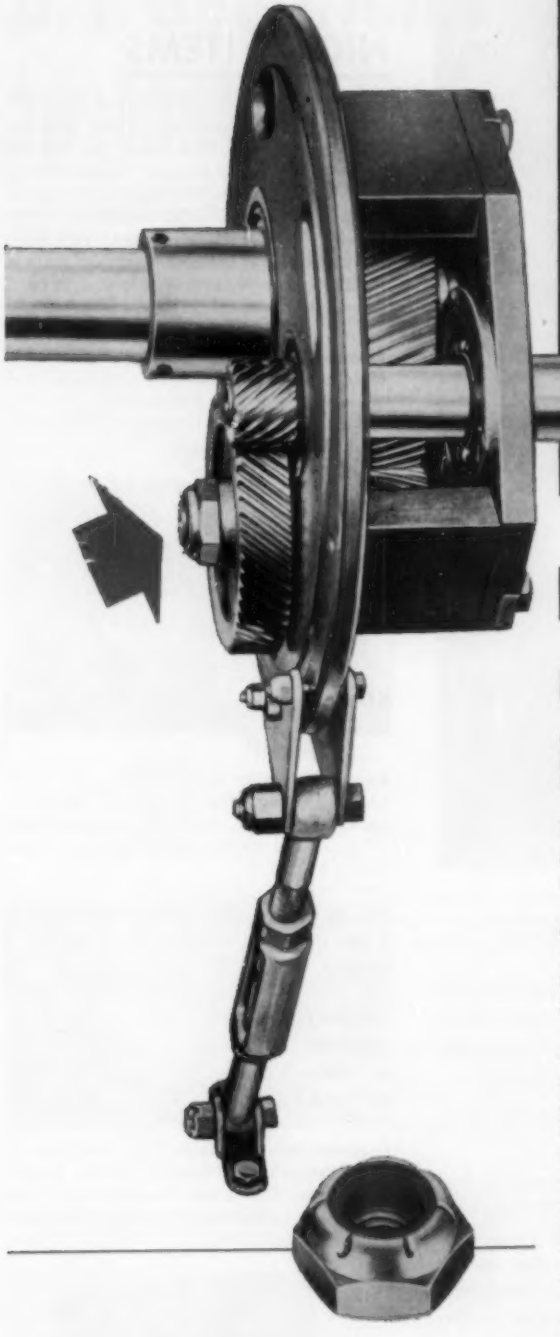
A Mallory engineer will be glad to discuss your particular problem. Write or call today for a consultation, and for a copy of the Mallory Contact Catalog.

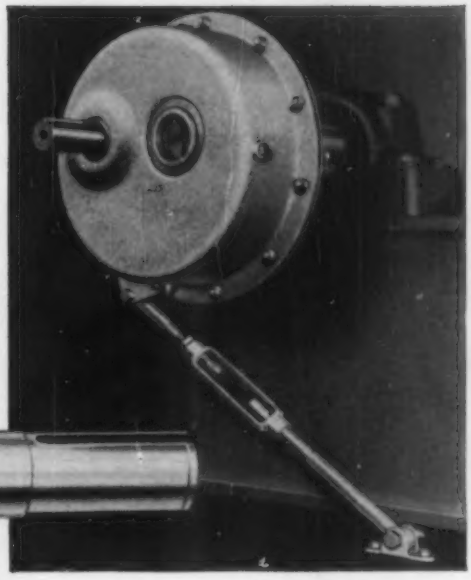
Expect more...
Get more from MALLORY

In Canada made and sold by Johnson Matthey & Mallory, Ltd., 110 Industry Street, Toronto 15, Ontario

Serving Industry with These Products:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA





The Falk Corp., of Milwaukee, also uses Elastic Stop nuts in the tie rod assembly . . . and on the gear housing to maintain tight cover fit.

Elastic Stop® nuts solve critical gear adjustment problem in new speed-reducing unit!

In its rugged new Shaft-Mounted Drive, The Falk Corporation uses a self-locking Elastic Stop nut to secure the high-speed gear to the intermediate shaft, as shown in the illustration on the left.

The precision-made Elastic Stop nut stays firmly in place and the close seat-squareness tolerances maintain the exact original gear adjustment withstanding severe vibration caused by shock loads transmitted through the gears. Costs are cut because drilled bolt holes and cotter pins are eliminated.

Here's how this Elastic Stop nut works: The familiar red collar of the Elastic Stop nut is deliberately undersized in relation to the shaft (or bolt) diameter. It grips the shaft with a perfect fit, enforces a continuing self-locking pressure against the metal threads, and holds the nut securely in place at the desired point on the shaft. This same tight-fitting locking collar also provides a seal that prevents oil from seeping along the bolt threads, wherever oil seepage is a problem. And because the bolt threads are protected against moisture from without, the nuts cannot become "frozen" to the bolt by corrosion. The elastic recovery of the red collar permits extended re-use of Elastic Stop nuts.

Mail the coupon for information on how Elastic Stop nuts can solve your specific fastening problem.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA® TRADE MARK

ROLLPIN TRADEMARK

Elastic Stop Nut Corporation of America
Dept. N67-12, 2330 Vauxhall Road, Union, N. J.
Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

CAUGHT!—by Silent Sounds

Suddenly, the lights snap on. Someone yells —

"Don't move or we shoot!"

How had the burglar been detected? No one saw him enter. No sign of an alarm system.

No obvious sign, that is. But there *was* an Alertronic Burglar Alarm.

This unusual protective device operates by sending out 19,200 cycle-a-second sound waves, too high for human ears to hear. The slightest movement of an intruder disturbs these waves and activates the alarm.

What produces the vibrations? Two slender nickel rods — and a principle of physics called magnetostriction (the peculiar way nickel changes length in a changing magnetic field).

Putting magnetostriction to work in this ultrasonic burglar alarm wasn't an overnight job. The inventor made his first experiments twelve years ago.

The search for a material with necessary magnetostrictive properties ended when he came to Inco. Nickel proved to be the material he was seeking.

And, as it turned out, he got more than a metal from Inco . . .

In the years that have passed, he has found Inco always ready to help in supplying information on the properties of Inco Nickel Alloys and other metals . . . on the technical aspects of magnetostriction . . . and on questions involving metal fabrication.

This same type of friendly cooperation, of course, is yours for the asking. Let's get together on your problem.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

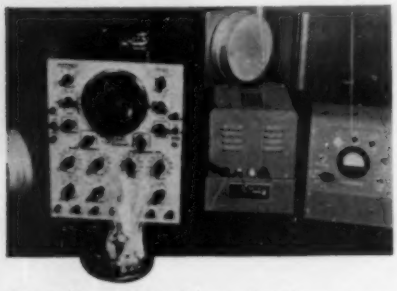
Inco Nickel Alloys

MONEL® • "R"® MONEL • "K"® MONEL
"KR"® MONEL • "S"® MONEL • INCONEL®
INCONEL "X"® • INCONEL "W"®
INCOLOY® • NIMONIC® ALLOYS • NICKEL
LOW CARBON NICKEL • DURANICKEL®

NICKEL ITEMS

Who can guess what new use of magnetostriction will be announced next? Nickel transducers from little rods the size of match sticks up to ton-size blocks are already being used for killing germs by silent sounds, to measure ocean depths, to locate fish, for dust precipitation, for faster drilling of wells, for shaping gems and cutting tool materials so hard they normally have to be cut laboriously with diamonds.

When installed according to specifications of insurance underwriters and connected to central protective system, Alertronic enables users to qualify for 60% reduction in insurance premiums.



Even the motion of heated air from burning wad of paper in ash tray sets off Alertronic alarm as pictured by jumping lines of the oscillograph tube in this demonstration set-up.

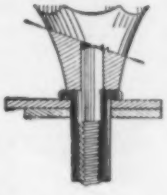
Inventor Samuel Bagno, Vice President of The Ultrasonic Division of Walter Kidde & Co., Inc., flips a switch as he leaves his own plant to connect the alarm unit into Central Patrol Office.

If you really want more facts and technical data on the magnetostrictive properties of nickel, ask for our bulletin "Magnetostriction." It is written for engineers and physicists.

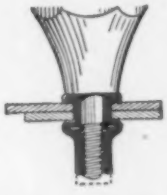
B. F. Goodrich RIVNUTS give new way to fasten leveling feet... cut costs!

Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

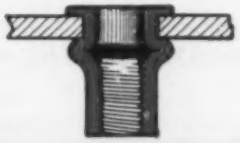
4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

Compare these 4 methods of putting screw threads in thin sheet metal

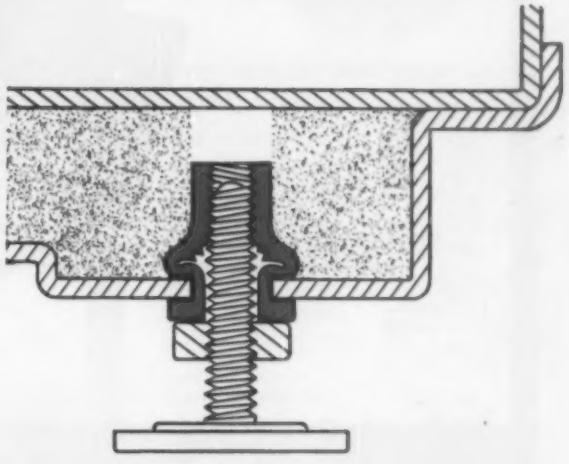
Tapped—2 threads

Pierced and tapped—3 threads

Projection welded—4 threads



Rivnut—at least 6 threads



APPLIANCE DESIGNERS were looking for a way to fasten leveling feet to the bottoms of refrigerators, stoves and automatic washers. The metal was too thin to tap, and welding would warp it. Besides, the threads would be ruined in the enameling process.

All these problems were solved by a B. F. Goodrich Rivnut—the *only* one-piece blind rivet with threads! Working from one side of the cabinet, one man installs the Rivnut in a few seconds. The easy-to-use power heading tool forms a bulge in the Rivnut shank—a "second head" that tightly grips the material. At least six threads remain clean to take the leveling-foot screw—more than enough to take the heavy loads. Installation is made *after* enameling without marring the finish.

Besides these advantages, the quick, simple installation of Rivnuts saves time, cuts assembly costs. For help on your fastening problem, write The B. F. Goodrich Company, Dept. PE-15, Akron, Ohio.

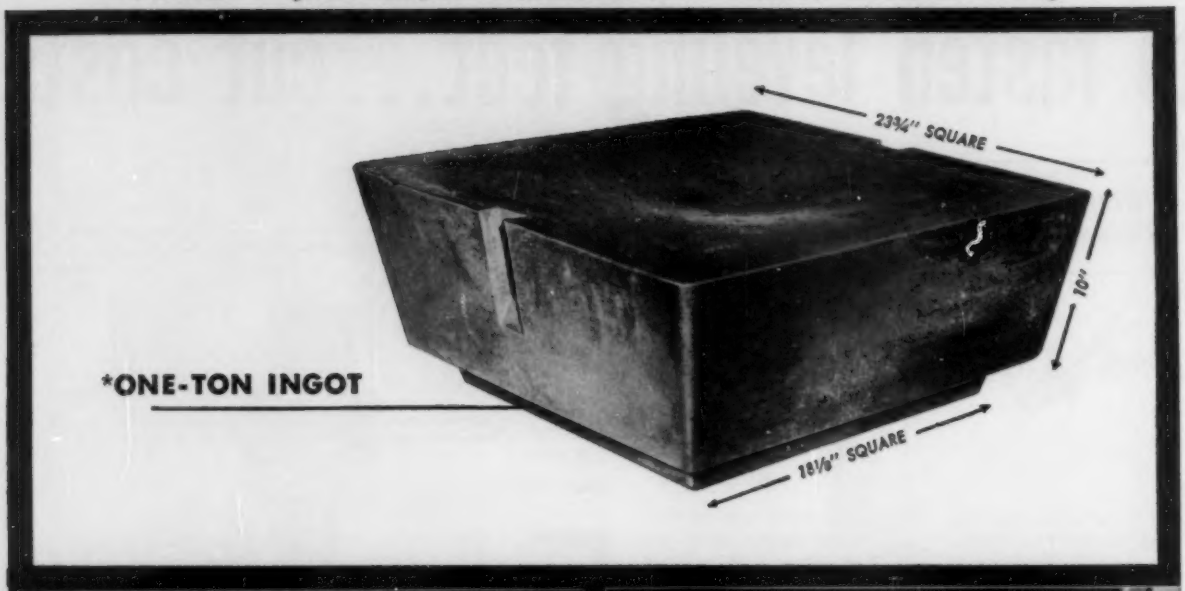
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives proved applications . . . Write for your free copy today to The B. F. Goodrich Company, Department PE-15, Akron, Ohio.

B.F.Goodrich RIVNUT

The only one-piece blind rivet with threads

the "New Look" in Lead*



Method of handling and stacking one-ton lead ingots by means of fork lift truck.

One end of freight car loaded with 50,000 lbs. of lead in units of 25 one-ton ingots.

THE ST. JOSEPH LEAD COMPANY is now ready to ship corroding lead to carload consumers in units of one-ton ingots. This "new look" in lead has been worked out successfully with a number of our customers who have now adopted it as a standard practice for their shipments. Assuming adequate melting capacity, the shipping of lead in one-ton ingots offers consumers these obvious economies:

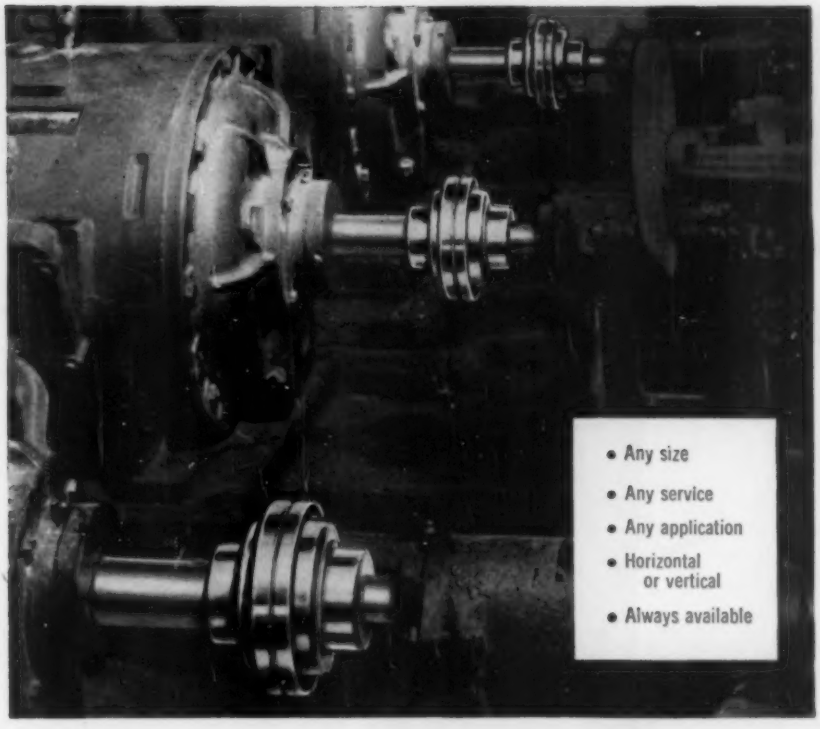
- *Strapping charges for the 2000 lb. to 2500 lb. "bundles" are eliminated.*
- *Shifting, dislocation or "scrambling" of cargo, due to strap breakage is avoided.*
- *Since delivery in "neat" package is ensured, handling costs and injury hazards are greatly reduced.*
- *Ingots are adapted to easy handling with ordinary fork lift trucks, and can be picked up from either direction.*
- *The compactness of one-ton units also makes possible a considerable increase in storage capacity.*

For improved materials handling at less cost, specify one-ton lead ingots for your shipments.

ST. JOSEPH LEAD COMPANY

The Largest Producer of Lead in the United States

250 PARK AVENUE, NEW YORK CITY 17, NEW YORK



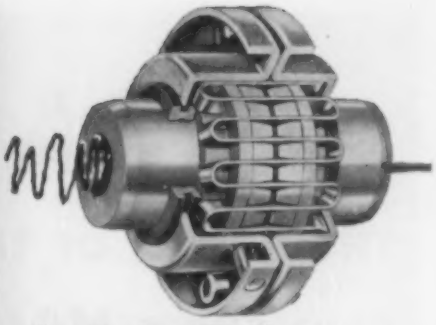
FALK Steelflex Couplings save you money by prolonging the work-life of connected machinery

Ever since the first Falk Steelflex Coupling was designed and built, more than thirty years ago, we have firmly held to these beliefs:

1. A coupling, to give fullest value, must do more than merely connect driving and driven machinery—it must protect the machinery and prolong its life.
2. A coupling, to be truly flexible, must overcome the effects of shock and vibration, as well as shaft misalignment (see column at right).

Proof of the soundness of these beliefs is furnished by the record. Many Falk Steelflex Couplings installed 10, 20, even 30 years ago are still giving trouble-free service—still providing maximum protection for the machinery they connect!

A single basic type—the world-famous Type F—fills nine out of ten industrial application needs. Versatile, efficient and economical, it is always quickly available, in a wide range of sizes, regardless of your location. Write to Department 247 for engineering bulletin, including selection and dimension details.



How Torsional Resilience smothers shock and vibration

The steel gridmember connecting hubs fits snugly only at outer edges of tapered hub-teeth. As load increases, gridmember flexes against teeth in proportion to load, providing cushion that spreads peak loads over longer time increment and reduces stresses in machinery.

UNDER NORMAL LOAD

ANGULAR MISALIGNMENT

...Accommodates shaft misalignment... Permits free end float

The exclusive FALK all-steel grid-groove design provides compensation for parallel and angular shaft misalignment . . . permits free end float.

PARALLEL MISALIGNMENT

FREE END FLOAT

Special or Dual Purpose FALK Steelflex Couplings for problem applications

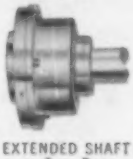
LIMITED SPACE
Type FS

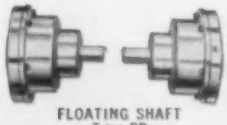
RAPID REVERSING SERVICE—Type CM

HIGH SPEEDS
Types H and HH

BRAKEWHEEL SERVICE
Type BW

OVERLOAD CONTROL
Type FT


EXTENDED SHAFT
Type P


FLOATING SHAFT
Type PP

Do you have a coupling problem?

If so, describe it in writing—we will gladly recommend the proper Steelflex coupling for your needs. Write to Department 247.

THE FALK CORPORATION, Milwaukee 8, Wisconsin

MANUFACTURERS OF

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry

GRAPHITAR® HELPS HARNESS

THE POWER OF THE ATOM IN NEW ATOMIC SUBMARINE *NAUTILUS*

GRAPHITAR is a carbon-graphite engineering material that has proved successful in hundreds of difficult applications.

- **GRAPHITAR** can be formed in relatively complicated shapes and ground to tolerances as close as .0005".
- **GRAPHITAR** is lighter than magnesium and harder than most steels. It is mechanically strong and durable and highly resistant to wear.
- **GRAPHITAR** is practically unaffected by high speeds, high altitudes, high pressures or temperature extremes.

OUR 100th YEAR

THE UNITED STATES

The Westinghouse Electric Corporation, working closely with the Atomic Energy Commission, has designed and built the nuclear power plant for the first atomic-powered submarine, the Nautilus. In atomic power operations, where radioactivity is a difficult problem, fluid systems must usually be hermetically sealed because conventional pumps with external drive motors are not adaptable to this type of operation. For the submarine's power reactor, Westinghouse engineers developed special hermetically sealed pumps with integrated pump and drive motor. The bearings in these pumps, which are made of GRAPHITAR, must withstand high speeds, high temperatures, high pressures and must also operate for indefinite periods of time without maintenance with radioactive hot water as the only lubricant. All leakage past the pump seal is contained within the flooded motor while the purely electrical elements are contained in "cans" to exclude water.

When the Nautilus is put into service, the power to run its conventional steam turbine, which is the actual driving power for the submarine, will come from atomic fires in the reactor where controlled nuclear fission produces enormous amounts of heat. The heat is transferred to the boilers through a closed circuit where the boiler water is turned into steam which is used for driving the turbine. Continuous, trouble-free circulation is extremely vital in this system and it is here that GRAPHITAR is proving its ability to help harness the power of the atom for the future good of mankind.

195

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

Some typical parts produced from HAYNES *alloys*

Custom Tailored to cut maintenance costs

Alloys for Every Wear Condition Shaped to Your Specifications

HAYNES alloys are available in a wide range of properties. They can be supplied as castings, forgings, stampings, or fabricated parts finished to close tolerances and with a mirror-like finish where required.

Some HAYNES alloys are extremely hard—to resist severe abrasion. Some are tough and ductile, designed for use where mechanical shock or repeated stress cause ordinary metal parts to crack and splinter. Some resist the corrosive action of acids, alkalies, and molten metals. Erosion from steam or liquids, the softening effects of high-temperatures, seizing and galling from metal to metal contact, are other severe conditions that can be effectively controlled through the use of HAYNES alloys.

Send us a blueprint of one of your wearing parts and tell us about the conditions under which the part must operate. We are sure we can supply you with a HAYNES alloy part "custom tailored" to solve your problem.

"Haynes" is a registered trade-mark of
Union Carbide and Carbon Corporation.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

FLEXIBILITY

CHEMICAL RESISTANCE

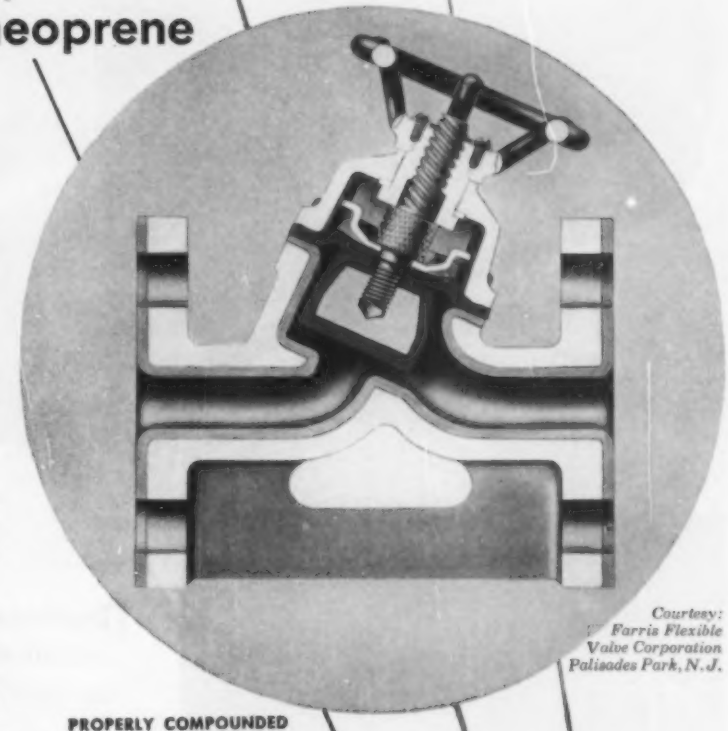
ABRASION RESISTANCE

These properties of neoprene make a better DIAPHRAGM VALVE

Designers made this valve doubly effective for abrasive, corrosive or vacuum services. For, unlike ordinary diaphragm valves, it has *two* separate elements for the jobs of sealing and seating. A flexible neoprene diaphragm seals off the valve's upper mechanism, while a replaceable seating disk surfaced with neoprene gives positive closure—*independent* of the diaphragm.

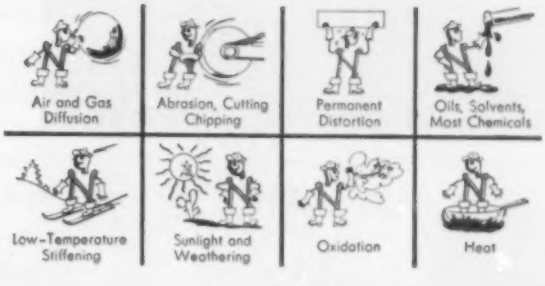
The neoprene diaphragm retains its flexibility even when exposed to oil and grease or corrosive chemicals in the line. And since this design does not subject the diaphragm to seat wear, it stays intact to perform its sealing function through a longer service life. The replaceable seating disk is surfaced with ample thickness of neoprene for closure over fine grits. And the neoprene resists abrasion and corrosion . . . has the lasting resilience required for a tight seal.

Frequently the entire valve is lined with neoprene when severe chemical service is expected. This liberal use of Du Pont neoprene offers further proof of the confidence designers have in the balanced combination of properties which neoprene offers . . . to make a better design or to develop an entirely new solution to a problem.



Courtesy: Farris Flexible Valve Corporation Palisades Park, N.J.

PROPERLY COMPOUNDED NEOPRENE WILL RESIST:



NEOPRENE

The rubber made by Du Pont since 1932

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

***FREE!* THE NEOPRENE NOTEBOOK**

Each issue shows new, unusual applications of neoprene . . . new products . . . improved designs. The neoprene application cited above is covered in Notebook No. 58. Add your name to the mailing list today.

E. I. du Pont de Nemours & Co. (Inc.)
Rubber Chemicals Division PE-1, Wilmington 98, Del.

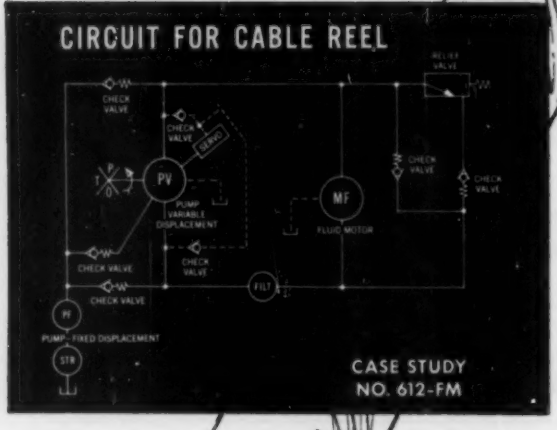
*Name*_____ *Position*_____

*Firm*_____

*Address*_____

*City*_____ *State*_____

Shock loads can't hurt this fluid motor



Denison Axial Piston Fluid Motors recommended for the toughest jobs . . . without qualification

● Quick starts, quick stops, stalling under load, continuous braking. These are the kind of conditions Denison Fluid Motors are built for. Where other motors fail, Denison hydraulic motors operate continuously . . . in conveying equipment, mining, drilling, construction machinery.

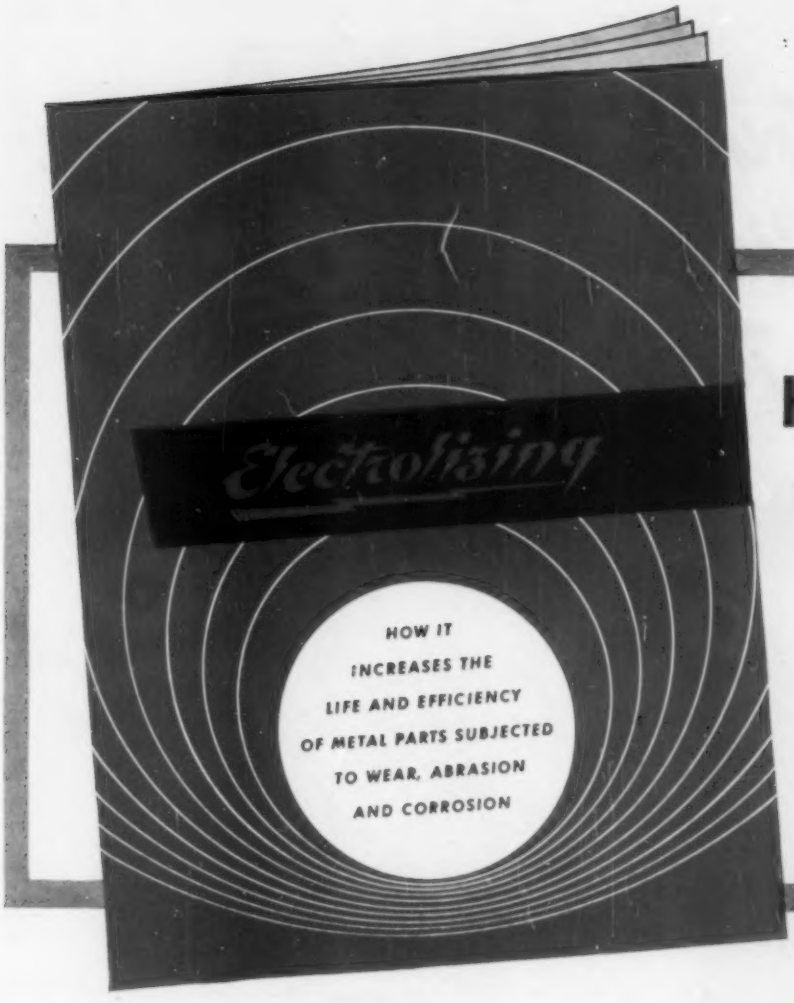
Through efficient axial piston design, Denison hydraulic motors pack high horsepower, high torque in a smaller space. The 400 series fluid motor is less than a foot long, weighs only 40 pounds . . . yet delivers 24 horsepower.

Denison Fluid Motors can be furnished to develop up to 180 horsepower, 5665 pounds-inches torque . . . for any hydraulic circuit to 5000 psi.

The circuit shows a Denison Fluid Motor that reels cable in and out of oil wells. For bulletins about Denison Fluid Motors, write to: THE DENISON ENGINEERING COMPANY, 1194 Dublin Road, Columbus 16, Ohio.

PUMPS • MOTORS
CONTROLS • PRESSES

DENISON
TRADE MARK
hydrOILics



How to Increase Wear Part Life 2 to 10 Times...

Without Changing Design, Materials or Methods

YOU can increase the life of wear parts 2 to 10 times without a single change in design, materials or methods. Highly regarded manufacturers of everything from home appliances to military equipment are doing it with Electrolizing after trying conventional treatments without success.

Electrolizing increases the surface hardness of ferrous and non-ferrous metals, reduces friction to a remarkable degree and provides exceptional resistance to wear, abrasion and galling.

The 16-page booklet pictured above answers nearly every question you might ask about the Electrolizing process. Applications . . . typical case histories . . . why Electrolizing does not warp or distort parts . . . how high surface hardness is obtained . . . why Electrolizing does not adversely affect the mechanical properties of the base metal . . . how dimensions are held to a tolerance of .000025"—these are a few of the basic points covered. There are many more.

Send for your free booklet today. It may contain the answer to your friction, wear and abrasion problems. There is no obligation . . . use the convenient coupon.

THE Electrolizing CORPORATION

1505B East End Avenue, Chicago Heights, Illinois

Other Plants:

Providence, R. I. 148 W. River St.
Cleveland, Ohio 1325 E. 152nd St.
Los Angeles 21, Cal. 1406 East 15th St.

The Electrolizing Corporation
1505B East End Avenue, Chicago Heights, Ill.

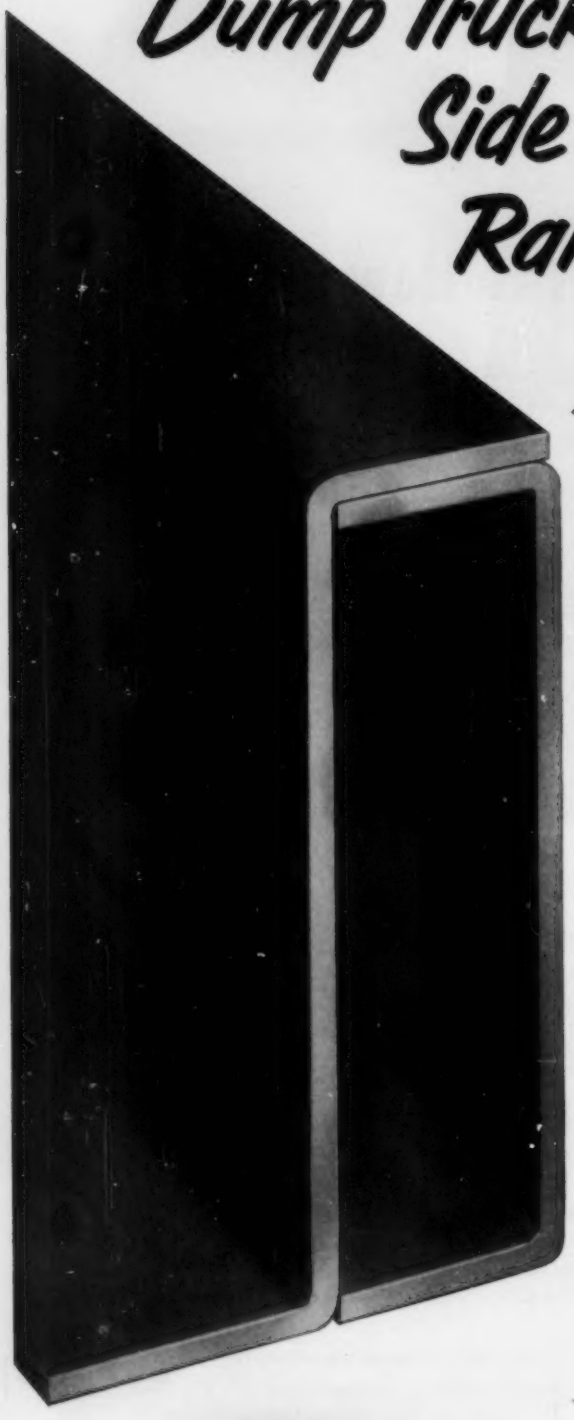
Name.....

Company.....

Address.....

City.....Zone....State.....

Dump Truck Side Rails



made from Cold-Formed Shapes

These two sturdy shapes — a Z section and a channel — form a rigid base to support the body-tilting sections of hydraulic dump trucks. Formed cold from steel sheets, they are supplied to the manufacturer in lengths of approximately 10 ft. Installation of these shapes on the truck bodies requires a minimum of preparation and shop work, since they are formed accurately to customer specifications.

Cold-Formed Shapes in Your Product

There's a good chance that you can use a Bethlehem Cold-Formed Shape to advantage in your product. The possible applications of these shapes are almost limitless — lately we've made them for use in ornamental railings, storage racks and industrial conveyor systems, to name only a few.

Bethlehem Cold-Formed Shapes come in any gage of strip, sheet or plate steel from 5 to 24. The most simple of pencil sketches submitted with your inquiry will enable our engineers to turn your idea into a practical and economical product.

A request to the nearest Bethlehem sales office will bring you our booklet on Cold-Formed Shapes. Or our representative will be glad to call on you and discuss your needs in detail.

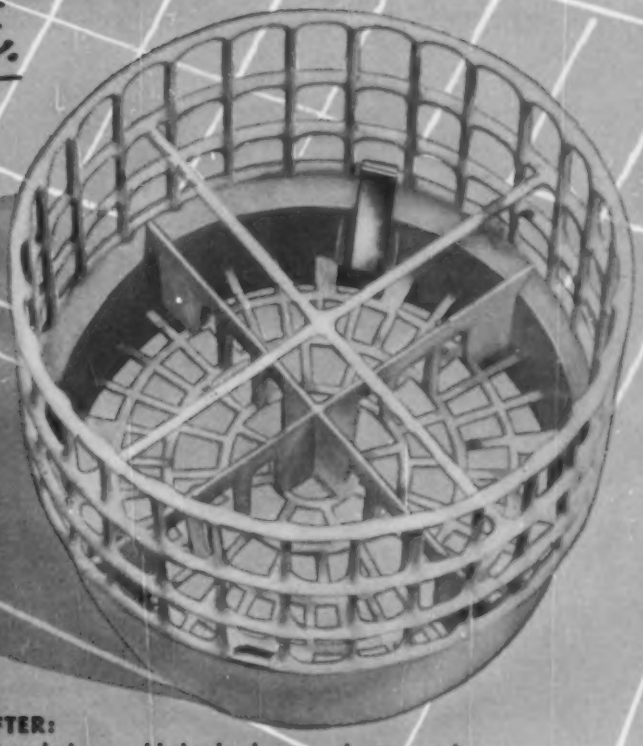
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

How to make a good product even better (at lower cost, too) with plastics parts by G.E.

BEFORE:
Silverware holder—vinyl-covered wire . . . metal band around base



AFTER:
New design—molded nylon base . . . less expensive

BETTER PERFORMANCE AT LOWER COST! This silverware holder for an automatic dishwasher was originally designed as a two-piece unit using vinyl-covered wire and a metal band. Working with the customer, G-E plastics engineers redesigned the base as a single unit molded in nylon. **RESULT?** The following customer benefits: improved distribution of water for better cleaning . . . better positioning of silverware . . . smarter appearance . . . substantial cost savings.

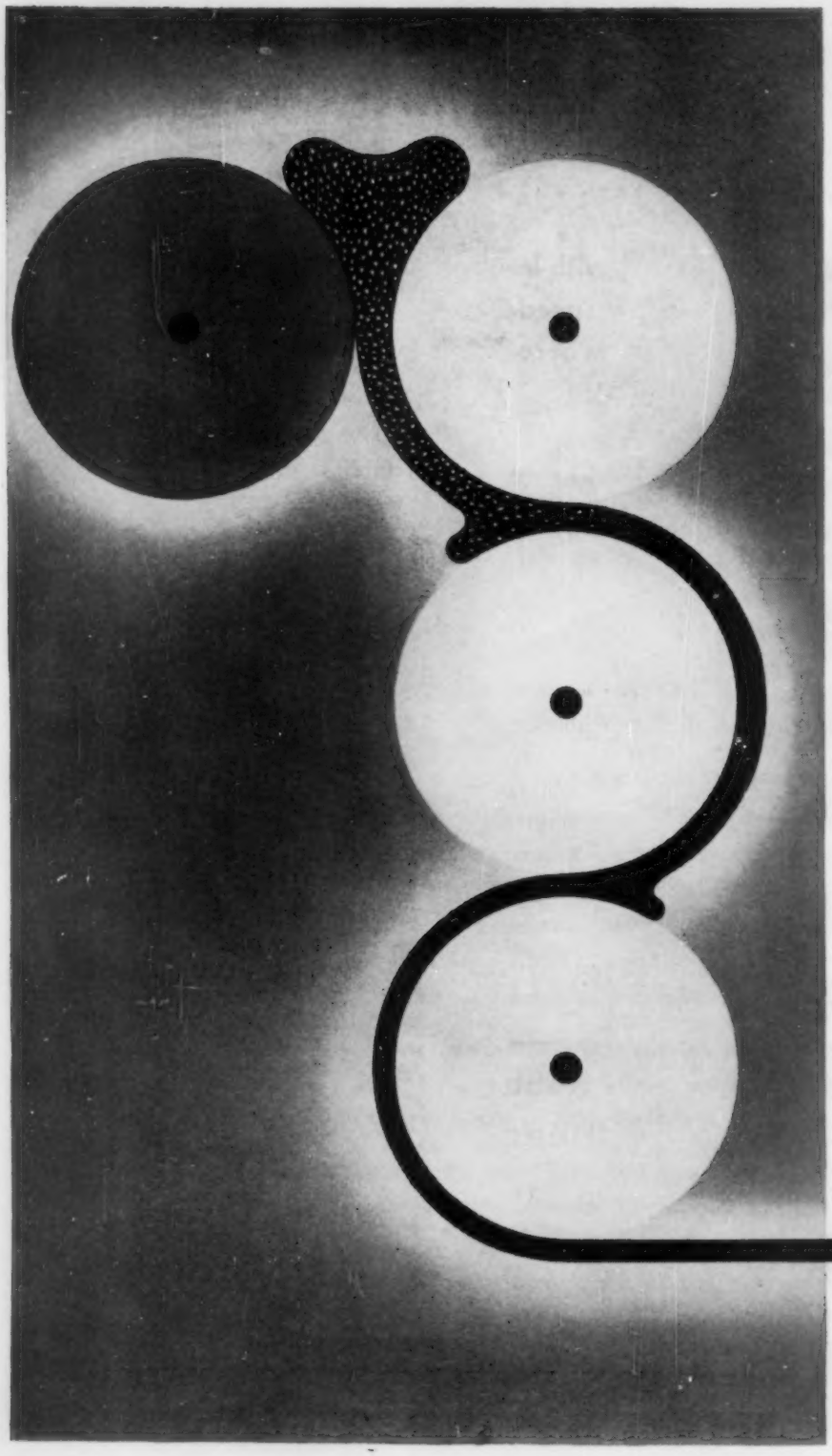
Are you a large-volume manufacturer of parts or products? If so, G-E plastics engineers would like an opportunity to help *you* improve designs, cut costs, add sales appeal to products. *Let's talk it over!*

Write: Plastics Department, General Electric Company, Pittsfield, Mass.
Plants at Decatur, Illinois—Taunton, Massachusetts 550-1B

Progress Is Our Most Important Product

GENERAL ELECTRIC

and now...



new

It's an outstanding new calendering resin—designed to meet the industry's demand for processing speed —that gives...

MARVINOL VR 30

- a "dry" premix even in unheated mixers with large amounts of plasticizers
- much faster fluxing with higher calender speed possible
- soft, smooth rolling banks with a minimum of cold streaks
- extremely high oil absorption
- reduced molecular weight
- the easy processability of a vinyl copolymer
- the physical properties of a straight polyvinyl chloride
- extremely fast solution rate
- excellent inherent heat and light stability

Particularly advantageous for film, sheeting, and fabric coating, this soft calendering resin also exhibits excellent extrusion qualities, with good gloss, clarity, and smoothness.

Try this advanced straight polyvinyl chloride resin in your *own* operations. See why those who have already used new Marvinol VR 30 have been more than pleased with the results...and have enthusiastically come back for more.

For more technical data on new Marvinol® VR 30, simply write on your letterhead to the address below.

NAUGATUCK

Naugatuck Chemical

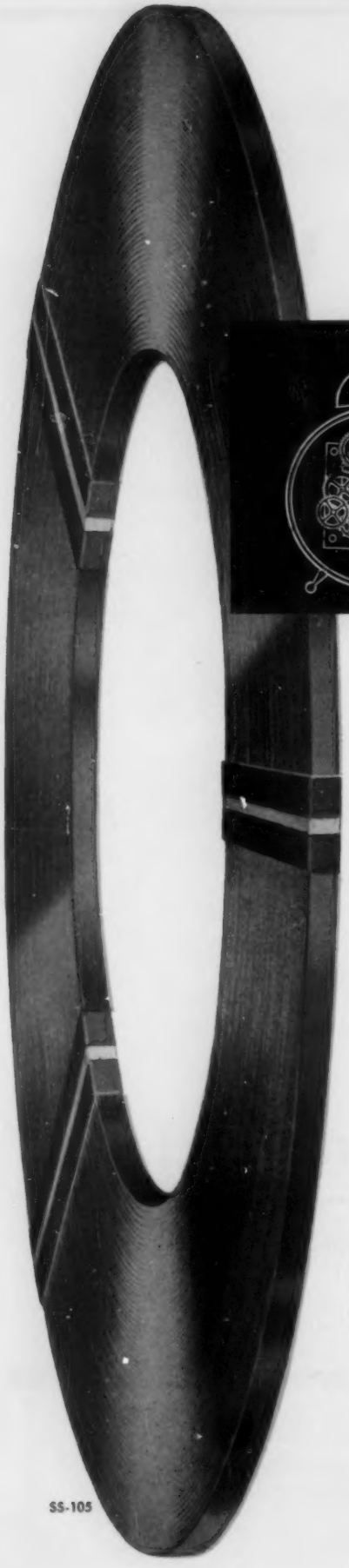
Division of United States Rubber Company
Naugatuck, Connecticut

US RUBBER

BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario
Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N. Y.

One of the original sponsors of the Vinyl Film Standard of Quality, Naugatuck Chemical pledges its earnest and continued support of the program.

VINYL FILM



For Years of Repeat Performance

specify SANDVIK SPRING STEEL

Sandvik Steels have a record of success in applications which demand years of consistent, continuous performance.

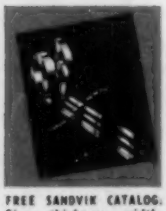
In products such as clock and watch springs, compressor valves, piston ring springs, vibrator reeds . . . wherever fatigue life is *vital*, you'll find Sandvik untiring in service.

If your product requires high fatigue life, fine surface finish, uniform physical properties and accurate gauge, try Sandvik.

You can get Sandvik strip steels:

- **In special analyses for specific applications.**
- **Precision-rolled in thicknesses to fit your requirements.**
- **In straight carbon and alloy grades.**
- **Annealed, unannealed or hardened and tempered.**
- **Polished bright, yellow or blue.**
- **With square, round or dressed edges.**
- **Wide range of sizes in stock—also slitting facilities available.**

Ask your nearest Sandvik office for further information or technical assistance.



FREE SANDVIK CATALOG. Gives thickness, width, hardness, type of edge and weight in pounds per hundred ft. Write for your copy.

SANDVIK SWEDISH SPECIALTY STRIP STEELS
are used for Textile Machine Parts such as sinkers, needles, etc. • Band Saws (metal, wood and butcher) • Camera Shutters • Clock and Watch Springs • Compressor Valves • Doctor Blades • Feeler Gauges • Knives such as cigarette knives, surgical, etc. • Razor Blades • Shock Absorbers • A Wide Variety of Springs • Trowels • Reeds: Vibrator, Textile, etc., • Piston Ring Segment and Expanders • and many other applications.

SANDVIK STEEL, INC.
111 EIGHTH AVE., N. Y. 11, N. Y. • Watkins 9-7180
230 N. Michigan Ave., Chicago 1, Ill., FRanklin 2-5638
1736 Columbus Rd., Cleveland 13, Ohio, CHerry 1-2303
3609 E. Olympic Blvd., Los Angeles 23, Cal., ANgelus 3-6761
SANDVIK CANADIAN LTD., P. O. Drawer 430, Station O, Montreal 9, P. Q.
SANDSTEEL SPRING DIVISION • New York • Industrial Springs
SANDVIK SAW & TOOL DIVISION • New York • Saws and Tools

Sandvik Quality Steels

SS-105

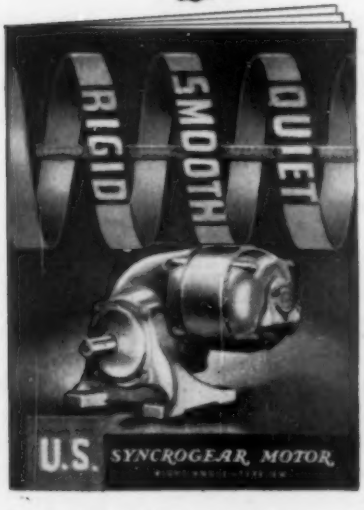
CAN'T DISTORT, CAN'T MISALIGN, ...because it has CANTILEVER DESIGN!

RIGHT-ANGLE
WORM-GEAR
SOLID CAST UNIBASE
PYRAMIDAL SUPPORT
CLOSE-HITCH
SEALED PROTECTION

U.S. NEW TYPE GW SYNCROGEAR MOTOR

Mounting stresses absorbed. Gear and motor distortion-free.

Permanently accurate gear and bearing alignment are vital in any right-angle, worm-gear motor. In the amazing new Type GW Syncrogear motor the *cantilever* principle is employed. Why? —To prevent stress of motor and gear mounting. A solid-cast Unibase pyramidally supports the entire load. Type GW is extremely compact. Gear is sealed in dustproof case. Speeds, 20 to 155 r.p.m. Gear ratios up to 87:1. Horsepower, ¼ to 2.



HOW U. S. CANTILEVER DESIGN INSURES ALIGNMENT

U. S. MOTOR DESIGN

Motor and gearing mounted on single base. Cantilever position of motor is independent of external mounting stresses. Uneven floor mounting can't set up stress.

ORDINARY DESIGN

Gear and motor units mounted between two separate brackets permit distortion by bolting to irregular mounting surfaces.

New multi-colored descriptive booklet gives full engineering details

U. S. ELECTRICAL MOTORS Inc.
Los Angeles 54, Calif. • Milford, Conn.

MAIL COUPON for this new free SYNCROGEAR BOOKLET

REQUEST FOR TYPE GW SYNCROGEAR BOOKLET
U. S. Electrical Motors Inc. PDE-1
P. O. Box 2058, Los Angeles 54, Calif. or Milford, Conn.
NAME_____
COMPANY_____
ADDRESS_____
CITY ZONE STATE

Taking the noise out of sound

3M COMPANY

With movable wall panels, like those pictured above, you can build a room anywhere—in the factory, in the office, in the laboratory. But the new room would be impractical unless it were protected from outside vibration and noise. That's where 3M comes in.

EC-1000 is a vibration and sound damping coating that withstands high temperatures directly after application. Immediately after EC-1000 is sprayed on the back side of the metal panels, they are primed and run through the baking ovens! There's no lost motion . . . no production line slowdown. And once installed, walls treated with EC-1000 make a room that is quieter, easier to work in, relatively unaffected by external noise and vibration.

See what adhesives can do for you...

Perhaps you have a production problem 3M can help you solve. A 3M field engineer will be glad to consult with you on your specific requirements. Or, for a free booklet on cost-cutting 3M adhesives, write 3M, Dept. 41, 417 Piquette Ave., Detroit 2, Mich.

ADHESIVES AND COATINGS DIVISION **MINNESOTA MINING AND MANUFACTURING COMPANY**

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 122 E. 42 ST., N. Y. 17, N. Y. • CANADA: LONDON, ONT.

MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE ADHESIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

"Texas Special" locomotive and cars molded by **The Lionel Corporation,** Irvington, N. J.
Golden Tuba molded by **Emenee Industries, Inc.,** 200 Fifth Avenue, New York, N. Y.
Regina Electrikbroom Jr. sold by **Marilyn Products, Inc.,** Irvington, N. J.

High-Impact Styrene toys head the play for bigger markets

Beginning to notice the new shock-resistant styrene plastic toys this year? Look at these, made from BAKELITE High-Impact Styrenes. Big and small, they're handsome, durable, impressive examples of better products designed for improved sales.

Two BAKELITE High-Impact Styrenes are available for injection molding. TMD-5151 offers 8* times the impact resistance of general purpose styrenes. TMD-2153, the extra-high-impact material, has 18* times greater impact resistance. Manufacturers can make their choice based on fabricating costs and toughness required.

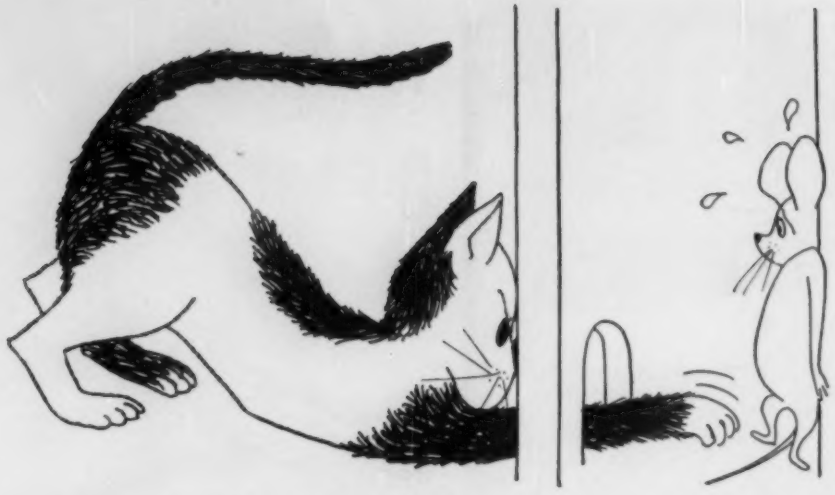
Get complete details on TMD-5151 and TMD-2153 by writing for your copy of BAKELITE Molding News, Vol. 1, No. 6. Also ask to be placed on the mailing list for this up-to-the-minute source of news in plastics.

*ASTM average Izod test using notched ⅛-in. bar at 75 deg. F.

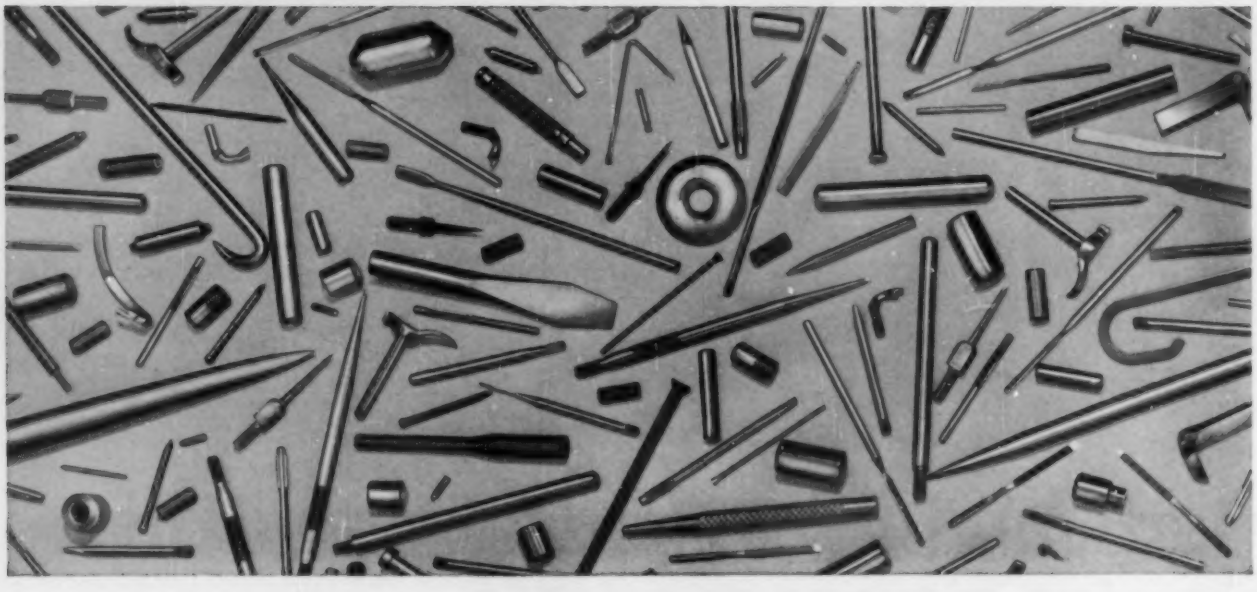
BAKELITE
TRADE-MARK
High Impact Styrenes

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, A Division of Union Carbide Canada Limited, Belleville, Ontario

GREATEST VARIETY . . . LARGEST RESOURCES FOR PLASTICS KEYED TO YOUR NEEDS
Impact Styrenes • Acrylonitrile Styrenes • Polystyrenes • Polyethylene
Phenolics • Vinyls • Epoxies • Polyesters • Fluorothenes



When Close Tolerances are Vital...
Call on **TORRINGTON** for Your Small Precision Parts



When you want "precision," you can count on Torrington. Almost 90 years devoted to producing metal parts exactly to the tolerances specified by customers assures you parts exactly "as ordered."

What's more, Torrington can give you the temper, hardness and finish you want—in any quantity—*faster, better and for less* than you can produce them yourself. Send your blueprint or a sample part for our quotation. And ask for our Condensed Catalog, showing many types of parts on which you can save.

THE TORRINGTON COMPANY
Specialties Division
230 Field Street, Torrington, Conn.

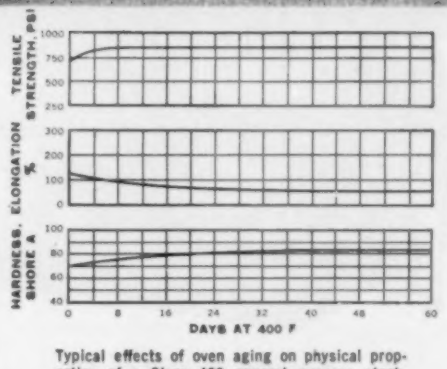
TORRINGTON *SPECIAL* **METAL PARTS**

Makers of Torrington Needle Bearings

CLASS 300 (LOW COMPRESSION SET)

Absolute minimum compression set at ordinary and elevated temperatures. Ideal for O-rings, seals, gaskets. *More "come-back"* than any known rubber!

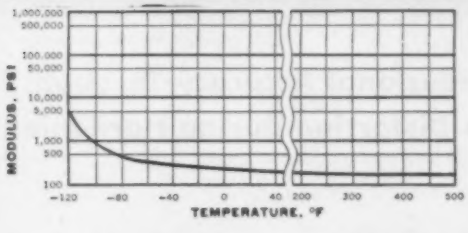
CLASS 400 (GENERAL PURPOSE)



Typical effects of oven aging on physical properties of a Class 400 general purpose stock.

Most economical class, providing typical silicone rubber properties for gaskets, seals, O-rings, sleeves, boots, bellows, tubing, belting, shock mounts.

CLASS 500 (EXTREME LOW TEMPERATURE)



Effect of temperature on flexibility of a typical Class 500 Extreme Low Temperature stock. (Young's Modulus in Flexure)

Flexibility and recovery from compression down to −120 F! Ideal for high-altitude flight applications where low-temperature flexibility is vital.

G-E silicones fit in your future

GENERAL ELECTRIC

Which class of

G-E SILICONE RUBBER IS BEST FOR YOU?

General Electric silicone rubber is classified *according to dominant property* to make it easy for you to select and specify the *right* silicone rubber for the parts you need. You can be sure of *more exact performance* when you choose among the many classes of G-E silicone rubber.

Send today *for free "Lightning Selector"!* This handy chart makes it quick and easy for you to select and specify the best G-E silicone rubber for your job.

General Electric Company
Section 53-1D
Waterford, New York

Please send me product data on G-E silicone rubber, including a free "Lightning Selector" and up-to-date list of fabricators. I am chiefly interested in:

1 ( ) Molded gaskets, bushings	9 ( ) Extruded seals, tubing
2 ( ) O-rings	10 ( ) Reinforced ducting, hose
3 ( ) Molded boots, sleeves, bellows	11 ( ) Sheets and blankets
4 ( ) Shock mounts	12 ( ) Rubber bonded to metal
5 ( ) Rubber-covered rolls	13 ( ) Die-cut gaskets
6 ( ) Belting	20 ( ) Wire and cable insulation
8 ( ) Sponged products	30 ( ) Coated tapes, cloths, sleeves

Name_____ Position_____

Firm_____

Street_____

City_____ Zone___ State_____

IN CANADA: Mail to Canadian General Electric Company, Ltd., Toronto

The
MEEHANITE CASTING REPORTER

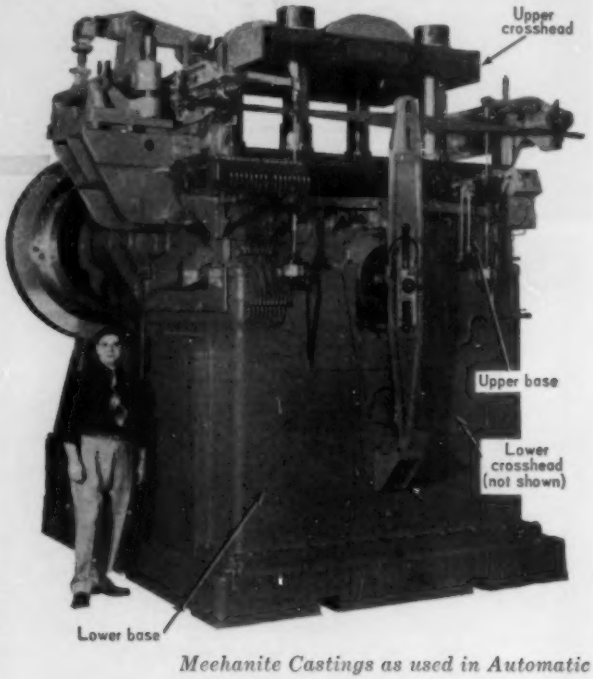
Industry reports what Meehanite Castings have done for them.

PRODUCTION MACHINERY

Maximum Safety Factor —Maximum Strength

Builder Says:

"We have used Meehanite castings ... to obtain close grained uniform castings of maximum strength ... as additional insurance against breaking."



Meehanite Castings as used in Automatic Dieing Machine
Henry & Wright Division
Emhart Mfg. Co., Hartford, Conn.

MACHINE TOOLS

Dimensional Accuracy Through Less Distortion During Hardening

Builder Says:

"With Meehanite castings ... less machining is involved and there is a minimum of distortion during the hardening process."

Broaching Machine
LaPointe Machine Tool Co.
Hudson, Mass.

HEAVY DUTY ROLLS

Increased Bending Capacity at Low Initial Cost

Builder Says:

"In addition to increasing plate bending capacity from 1 inch to 2½ inches the company saved thousands of dollars by designing and casting the rolls of Meehanite metal."

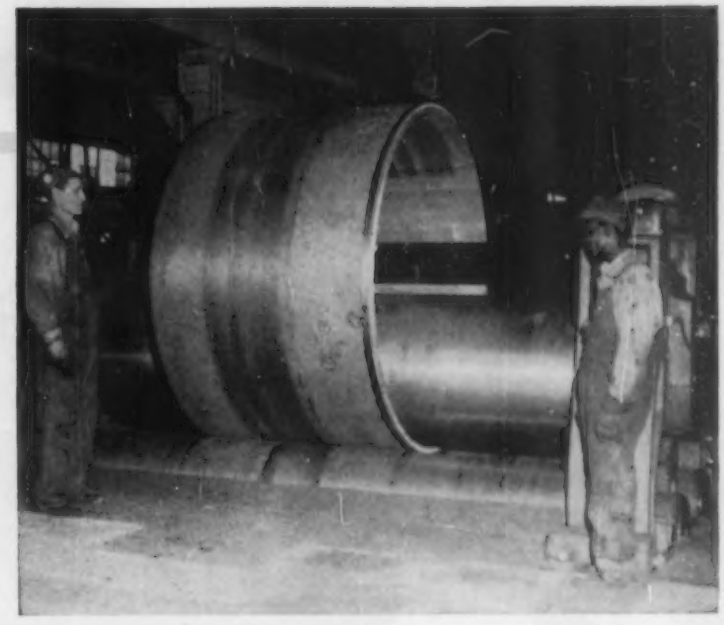


Plate Bending Machine using Meehanite Rolls bends 2¼ inch steel plate. General Iron Works Co., Denver, Colo.

ONLY A MEEHANITE FOUNDRY CAN MAKE MEEHANITE CASTINGS

American Brake Shoe Co. . . . . Mahwah, New Jersey
The American Laundry Machinery Co. . . . . Rochester, New York
Atlas Foundry Co. . . . . Detroit, Michigan
Banner Iron Works . . . . . St. Louis, Missouri
Barnett Foundry & Machine Co. . . . Irvington & Dover, New Jersey
E. W. Bliss Co. . . . . Hastings, Mich and Toledo, O.
Builders Iron Foundry . . . . . Providence, Rhode Island
Compton Foundry . . . . . Compton, Calif.
Continental Gin Co. . . . . Birmingham, Alabama
Crawford & Doherty Foundry Co. . . . . Portland, Oregon
The Cooper-Bessemer Corp. . . Mt. Vernon, Ohio & Grove City, Pa.
DeLaval Steam Turbine Co. . . . . Trenton, New Jersey
M. H. Detrick Co. . . . . Newark, N. J. and Peoria, Ill.
Empire Pattern & Foundry Co. . . . . Tulsa, Oklahoma
Farrel-Birmingham Co., Inc. . . . . Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. . . . . Florence, New Jersey
Fulton Foundry & Machine Co., Inc. . . . . Cleveland, Ohio
General Foundry & Manufacturing Co. . . . . Flint, Michigan
Georgia Iron Works Co. . . . . Augusta, Ga.
Greenlee Foundry Co. . . . . Chicago, Illinois
The Hamilton Foundry & Machine Co. . . . . Hamilton, Ohio
Hardinge Company, Inc. . . . . New York, New York
Hardinge Manufacturing Co. . . . . York, Pennsylvania
Johnstone Foundries, Inc. . . . . Grove City, Pennsylvania
Koehring Co . . . . . Milwaukee, Wisconsin
Lincoln Foundry Corp. . . . . Los Angeles, California
Palmyra Foundry Co., Inc. . . . . Palmyra, New Jersey
The Henry Perkins Co. . . . . Bridgewater, Massachusetts
Pohlman Foundry Co., Inc. . . . . Buffalo, New York
Prescott Co. . . . . Menominee, Michigan
Rosedale Foundry & Machine Co. . . . . Pittsburgh, Pennsylvania
Ross-Meehan Foundries . . . . . Chattanooga, Tennessee
Shenango-Penn Mold Co. . . . . Dover, Ohio
Sonith Industries, Inc. . . . . Indianapolis, Ind.
Standard Foundry Co. . . . . Worcester, Massachusetts
The Stearns-Roger Manufacturing Co. . . . . Denver, Colorado
Traylor Engineering & Mfg. Co. . . . . Allentown, Pennsylvania
Valley Iron Works, Inc. . . . . St Paul, Minnesota
Vulcan Foundry Co. . . . . Oakland, California
Warren Foundry & Pipe Corporation . . . Phillipsburg, New Jersey
Washington Iron Works . . . . . Seattle, Washington

Canada

Hartley Foundry Division — London Concrete Machinery Co., Ltd., Brantford, Ontario
E. Long Ltd., Orillia, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

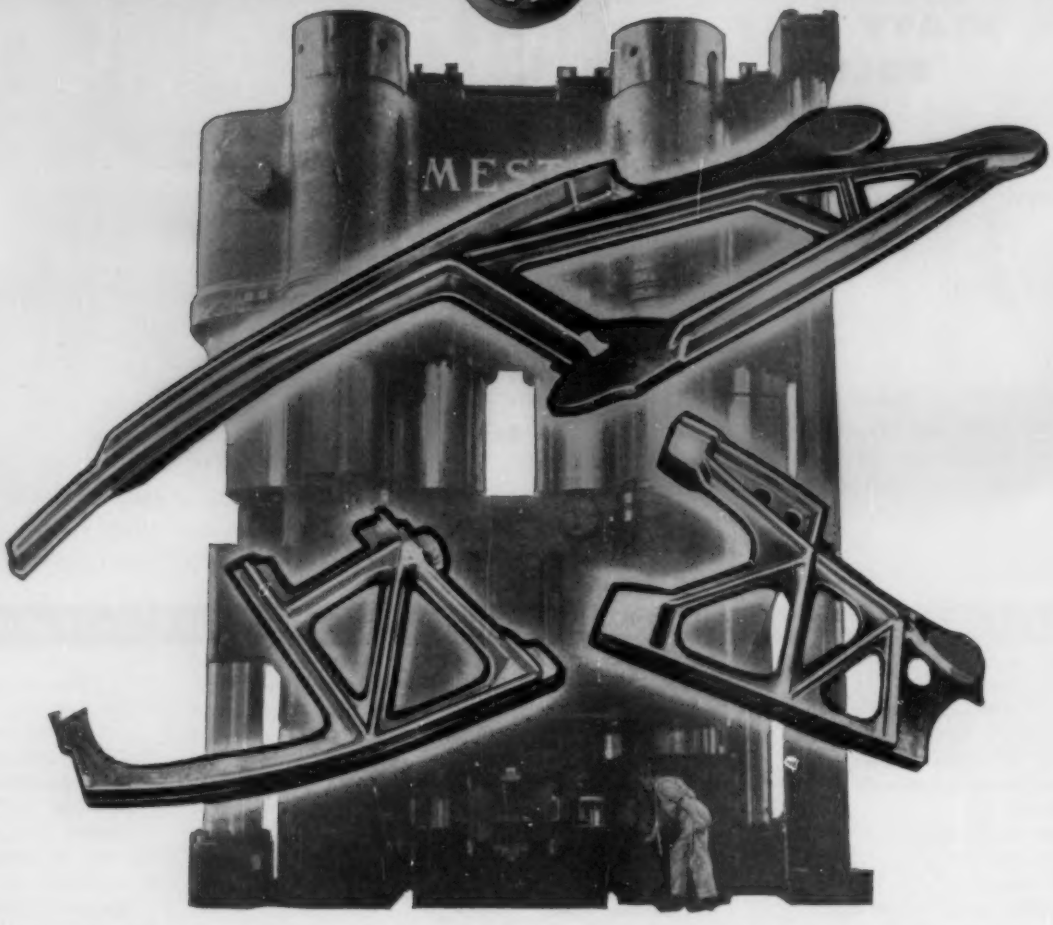
FOR SPECIFIC ENGINEERING PROPERTY DATA, WRITE

This advertisement sponsored by the above companies.

MEEHANITE.

New Rochelle, N. Y.

MEEHANITE MEANS METAL BETTER CASTING



Greater Size and Speed in Aircraft have created engineering problems, the solution of which has required larger and larger forgings of high-strength aluminum alloy. *Examples* shown above are forged structural members used in a modern military bomber, the largest more than seven feet over all. These are forged on an 18,000 ton press, the biggest ever built in this country.

Wyman-Gordon Experience—the most extensive in the industry—is keeping abreast of new forging demands involving the use of Steel, Aluminum, Magnesium, High Density Alloys and Titanium.

• • •

Standard of the Industry for More than Seventy Years

WYMAN-GORDON

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER, MASSACHUSETTS

HARVEY, ILLINOIS DETROIT, MICHIGAN

Miller HIGH PRESSURE HYDRAULIC CYLINDERS

HARD CHROME PLATED PISTON RODS
Prevent Scratch-Damage, Nicks and Rust

SOLID STEEL HEADS, CAPS and MOUNTINGS
Eliminate Breakage

DIRT WIPER SEALS
Protect Rods, Seals, Bushings

Standard Leather Cup Seal Assembly Shown Is Interchangeable With Miller Standard Piston Ring Piston Assembly

Thousands of Different Selections For Immediate Delivery!

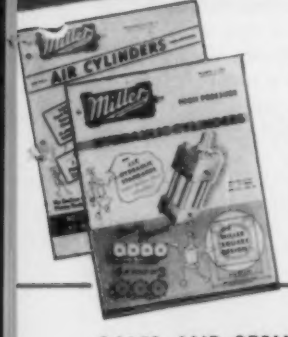
Rapidly expanding list of quality-famous Miller Cylinders for immediate, off-the-shelf delivery now includes thousands of different, popular selections—both hydraulic and air—cushioned and non-cushioned.

Bores up through 5″ hydraulic, 8″ air. Strokes up through 18″. Over 30 different mountings.

Larger bores (up through 12″ hydraulic, 20″ air) and longer strokes (up to 22 feet) available on longer delivery.

Miller Boosters also in stock for immediate delivery.

Write For Catalog and Stock List



WRITE FOR CYLINDER BULLETINS H-104 and A-105

Complete Miller cylinder line includes: air cylinders, 1½″ to 20″ bores, 200 PSI operation; low pressure hydraulic cylinders, 1½″ to 6″ bores for 500 PSI operation, 8″ to 14″ bores for 250 PSI; high pressure hydraulic cylinders, 1½″ to 12″ bores, 2000-3000 PSI operation. All mounting styles available.

MET J. I. C. HYDRAULIC STANDARDS years before their adoption in 1949.

SPACE-SAVING SQUARE DESIGN originated by Miller in 1945.

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY • BUFFALO • ST. PAUL • GRAND RAPIDS • DETROIT • FLINT • FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE • KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE • DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • TORONTO, CANADA and OTHER AREAS

Miller

MILLER FLUID POWER CO.
(formerly MILLER MOTOR COMPANY)

2002-04 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

Relief... for a production pain

Got an "ache" in your designs? Costs too high . . . production too low . . . product not competitive in price or performance?

For effective relief of production "pains," here's a suggestion. Take advantage of the practical, cost-saving application services offered by your Chain Belt District Engineer, and the outstanding performance of Chain Belt Products.

for example: A lift truck manufacturer was troubled by chain breakage and high over-all cost. His Chain Belt Man recommended a change to leaf chains which not only solved the breakage problem, but actually cut costs.

for example: A construction machinery manufacturer was experiencing considerable trouble due to premature failure of drive chains. His Chain Belt Man solved the problem with Rex Chabelco® Steel Chains designed to withstand the severe operating conditions.

for example: A manufacturer of packaging machines wanted an improved method of handling units through his machines. His Chain Belt Man recommended TableTop® Chain, a chain that provided a smooth, steady, tip-free conveyor, as level as a metal belt.

If your design "pains" involve driving, timing or conveying, your Chain Belt District Engineer can help you. From the complete Chain Belt Line of chains, sprockets, attachments and roller bearings, he can recommend the one best choice for your needs. Try him. Chain Belt Company, 4715 W. Greenfield Ave., Milwaukee 1, Wis.

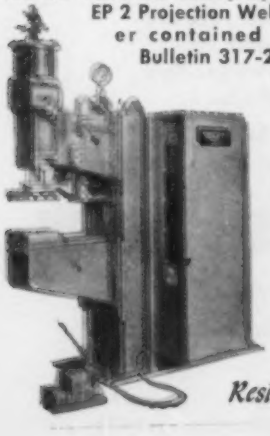
CHAIN BELT COMPANY

District Sales Offices in all Principal Cities

Sciaky Type EP 2 Resistance Welder at Berns Mfg. Co., Chicago, Illinois

NEW SCIAKY DESIGN . . . COMPETITIVELY PRICED

Write for complete specifications showing minimum to maximum welding capacities for the standard Sciaky Type EP 2 Projection Welder contained in Bulletin 317-2.



PRODUCTION JUMPS 420% . . .

One Standard Sciaky Welder Does the Work of Four!

With one welder Berns was producing only one-quarter the needed production of 29 piece, 10 gauge wire grills for their nationally known Air King Fan. Instead of selling three more machines, Sciaky provided the newly designed, standard EP 2 Welder equipped with simple tooling to replace the original machine. Production jumped 420% as one machine does the work of four plus, the customer has the original welder for other work.

Write for the complete details of Berns' impressive production increase and equipment savings as well as other similar examples of single welder applications contained in "Resistance Welding at Work", Vol. 4, No. 1.

These typical advantages of Sciaky resistance welding may well be applied to your fabricating operations. Welders designed to do *more useful work* at *lower operating cost* with *maximum reliability* is basic to Sciaky design.

Largest Manufacturers of Electric Resistance Welding Machines in the World

SCIAKY

Sciaky Bros., Inc., 4913 West 67th Street, Chicago 38, Illinois

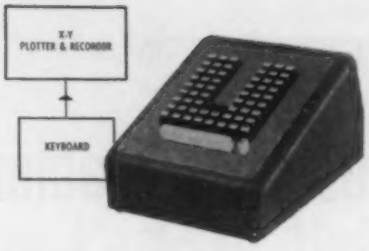
Design for economy with JOHNSON BEARINGS

IN THE VAST MAJORITY of applications Johnson Sleeve Bearings give long, troublefree service. Being one-piece bearings and precision made, they are economical in installation. Furthermore, they are low in first cost. Johnson Bearings are available in a wide range of bearing metals, alloys and combinations: aluminum on steel; bronze on steel; babbitt on steel or bronze; powder metallurgy; cast bronze; cast aluminum alloy; and sheet bronze, plain or graphited. No other manufacturer can furnish all of these types . . . that is why Johnson Bronze is known as "Sleeve Bearing Headquarters." Plan to save money with Johnson Bearings. Free engineering consultation is available. Write.

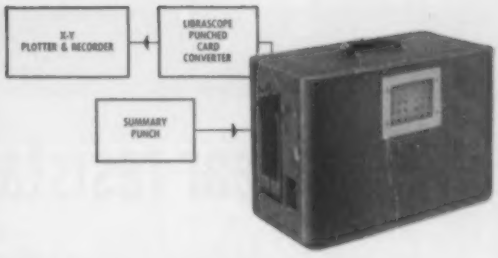
JOHNSON BRONZE COMPANY
508 South Mill St., New Castle, Pa.

JOHNSON B BEARINGS
Sleeve-Type

Sleeve Bearing Headquarters Since 1901



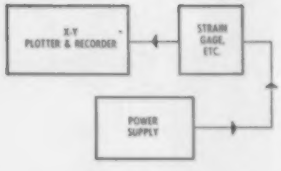
DECIMAL KEYBOARD: Consists of a three-decimal bank for each axis with associated plus-minus keys. Depressing plot bar initiates plot and clears keyboard automatically. Also manual clear button. Size: 8½ x 11 in., Weight: 12 Lbs.



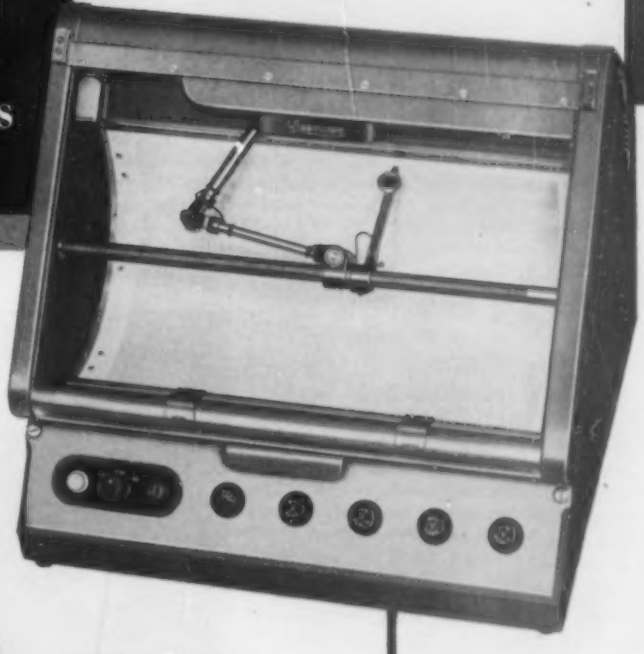
PUNCHED CARD CONVERTER: Converts punched card data to an analog form suitable for input to X-Y Plotter from Gang Summary or Reproducing punches. Display Monitor. Total tube complement 26 tubes.

X-Y plotter and recorder

simplified recording of two independent variables with greater selection of input devices



D.C. INPUTS: 5 millivolt full scale sensitivity on both axes. Infinite input impedance for signals to .5 volts, 2 megohms input impedance above .5 volts.



A compact, desk-size unit that accepts either analog or digital inputs. Standard digital converters: Decimal keyboard, Decimal punched card, and Binary for Computer Outputs. Handles remote mechanical shaft rotations directly without modification. Modifications available to customer specifications. Full chart visibility allows observer to view curve generation at all times. Unique pen travel for fast, dependable performance. Write for full catalog information.

DESCRIPTION:
Desk or Rack Mounted
(RCA or RMA)
Accuracy: .1%
Weight: 70 lbs.
Uses Standard Graph Papers:
11" x 16½", or 8½" x 11"
Power Consumption:
150 watts, 115 volts, 60 cycles

Engineers, physicists and mathematicians in search of interesting assignments, rapid advancement, and job security are requested to write Dick Hastings, Personnel Director.

Computers & Controls

LIBRASCOPE

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

LIBRASCOPE, INCORPORATED 1607 FLOWER STREET, GLENDALE, CALIFORNIA

DoALL *finds that Nickel Alloys combine needed properties such as:*

High wear resistance plus ready machinability

Nickel Cast Irons, Nickel Steels and Ductile Iron contribute to the ruggedness and wear-resistance of grinders . . . standard and special . . . produced by the DoALL Company, Des Plaines, Ill. Bases, tables, saddles, vertical slides, taper gibs, wear strips and sub-plate, on standard surface grinders are of 1½-2% nickel alloy iron. This iron is also used for similar important castings in the DoALL special rotor plunge grinder.

SPECIFY almost any logical combination of strength, toughness, hardness, corrosion resistance or other needed properties . . .

And you'll usually find a standard material that exactly answers both your fabricating and service demands from among the many grades of nickel alloys.

In fact, you'll probably discover . . . as DoALL did . . . that nickel alloys provide advantages which no unalloyed composition can match.

Properties combined in nickel-containing alloys contribute, for instance, to the efficiency of many components in the widely used DoALL grinders . . . both standard and special. Parts that must combine a high degree of wear resistance plus ready machinability, for example, are cast in alloy irons containing 1.50 to 2.00% nickel.

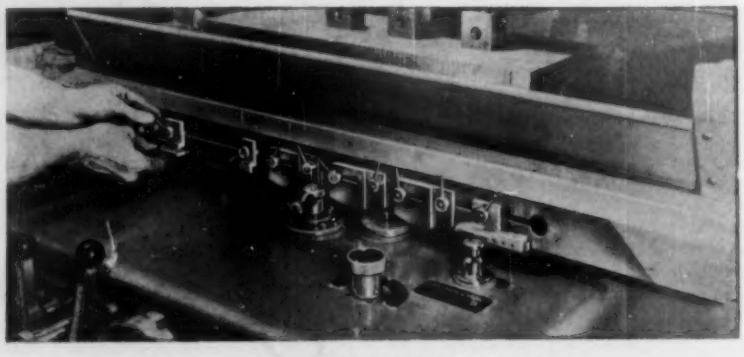
And components that call for resistance not only to wear, but also for some resistance to shock loads or sudden stresses, are cast in Ductile Iron fortified with about 1.50% nickel.

Spiral gears and arbors on standard DoALL types, and also pistons for special rotor grinders, are specified in a casehardened 8600 series nickel alloy steel. This grade of nickel-containing steel makes possible a wear-resistant surface supported by a core that resists fatigue and shock. A direct hardened steel of this same series is used for certain stressed gears in DoALL special grinders.

The advantages of weight saving, compactness, durability and strength . . . along with superior response to fabrication . . . may generally be obtained by using the correct nickel alloy. Whatever your industry, let us help you with your metal problems. Send us details for our suggestions. Write us today.

INCO
TRADE MARK

Ductile Iron trip dogs help DoALL grinders achieve peak precision and output. These components are easily spaced to speed up table motion desired between parts or jigs during slow "crush form" grinding of precision parts.



THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

DU PONT
REG. U. S. PAT. OFF.

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 1 — 1955

Camera Parts of Molded Du Pont "Zytel"* Nylon Resin Simplify Design, Reduce Wear

The new "Linex" stereo camera is sturdy and precision-engineered. Six parts of Du Pont "Zytel" nylon resin give lightness, strength, abrasion resistance and dimensional stability to key spots. Parts are molded economically, need no finishing.

Precision-molded "Zytel" needs no machining, lowers production costs

THE newest stereo camera is the "Linex", manufactured by the Lionel Corporation. This compact and precision-engineered camera features Du Pont "Zytel" nylon resin in six key parts.

Why is "Zytel" used? Engineers of the Lionel Corporation give several reasons. "Zytel" can be formed into intricate shapes by economical injection-molding. The pieces need no refinishing and can do the job of several parts in an assembly.

Lens shields, slide button, flash attachment, view finder and view finder housing—all molded of Du Pont "Zytel" nylon resin. The "Linex" camera is manufactured by the Lionel Corporation, Irvington, New Jersey.

Mechanical Properties Important

The mechanical properties of "Zytel" are important for this smooth-working camera. The shutter slide button has to stand up to wear and give long service. "Zytel" can do this because of its remarkable abrasion resistance. This engineering material is lightweight yet tough. Therefore, the lens shields and housing can be molded in thin sections that won't crack or break. And the flash bulb attachment, which is subjected to sudden high temperatures, is dimensionally stable—thanks to "Zytel".

The "Linex" camera is just one example of advanced product engineering—possible when design and service requirements are evaluated in terms of the properties of this unique engineering material. For further information on "Zytel" nylon resin, use the coupon on the back of this page.

OVER

Light-diffusing globe of Du Pont LUCITE® reduces breakage, resists weather

THE problem of breakage and maintenance of street light globes has been virtually eliminated by the development of a globe made of Du Pont "Lucite" acrylic resin. "Lucite" will not shatter, is lightweight, and easy to keep clean. After a two-year test, globes molded of "Lucite" showed no discoloration or other weathering effects.

Globes of translucent "Lucite" are efficient lighting fixtures. They diffuse light to reduce glare, while efficiently transmitting the light. Because of its excellent balance of properties, Du Pont "Lucite" can solve a wide variety of product design problems involving long-term light transmission and outdoor weathering. "Lucite" is fabricated economically by injection- and compression-molding, extrusion, and forming. For further information, use the coupon on the other side of the page.

This street light globe is made of non-shatterable Du Pont "Lucite" by Colt's Manufacturing Company, Hartford, Connecticut.

*"Zytel" is the new trade-mark for Du Pont nylon resin.

DU PONT
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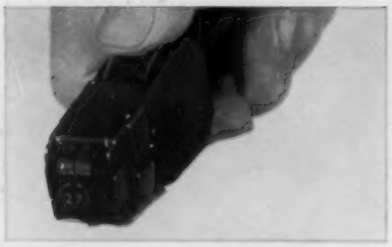
PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

NO. 1 — 1955

Non-stick TEFLON® used for anvil in band stamp

THIS new, self-inked band stamp needed a non-stick anvil over which the porous rubber band slides (see cut). With most materials, there is a tendency for the band to stick to the anvil when ink dries. Wearing qualities had to be considered. No sticking occurred when an anvil of filled "Teflon" tetrafluoroethylene resin was used. A test of the anvil's wearing properties showed no appreciable wear after 500,000 revolutions—at a rate of 10 revolutions a minute. And the "Teflon" was not affected in any way by the ink as other materials were.



Self-inked band stamp has anvil of filled "Teflon" which has non-stick and outstanding wearing properties. Anvil is made by Dixon Corporation, Bristol, Rhode Island.

Investigate Du Pont engineering materials in your product development programs

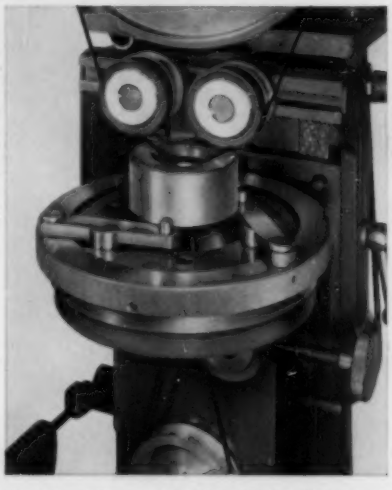
ONE of the family of these versatile engineering materials is often a key factor in product improvement or new design.

The wide range of properties available with "Alathon"* polyethylene resin, "Lucite"* acrylic resin, "Teflon"* tetrafluoroethylene resin, and "Zytel"† nylon resin are helping solve industrial design problems.

NEED MORE INFORMATION?

CLIP THE COUPON for additional data on the properties and applications of these Du Pont engineering materials.

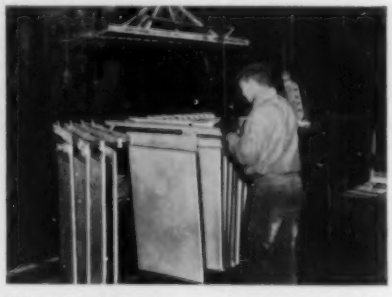
Sparkling transparency is a big sales feature of articles made of Du Pont "Lucite" acrylic resin. An example is this ruler, molded from "Lucite". It is easy to keep clean and sparkling, and keeps its shape for accurate measuring. This ruler comes packed in a bag of Du Pont "Alathon" polyethylene resin. This particular product is distributed by Brown and Bigelow of St. Paul, Minnesota.



Here is a diamond-studded belt of Du Pont "Zytel" nylon resin. Diamonds, the only agent hard enough to polish carbide dies, don't adhere properly to conventional polishing belts. Extruded "Zytel", however, provides a cushioning effect that keeps diamond grits from tearing out of their sockets. Tough "Zytel" resists wear so well that as many as 460 dies have been polished with just one belt. The belts are manufactured by the Hartford Special Machinery Company, Hartford 12, Connecticut.

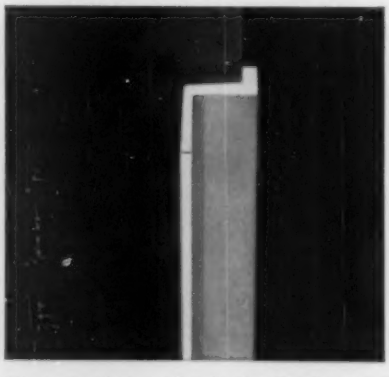
Zinc stripping of cathodes simplified with strips of ALATHON®

To economize their zinc stripping operation, engineers of a metal mining company have developed a new cathode strip of extruded Du Pont "Alathon" polyethylene resin. "Alathon" is not affected by the zinc sulfate solution which attacked and swelled the previous strip material. "Alathon" is tough and does not absorb moisture. Another advantage is its flexibility, which assures a tight snap fit on the cathode. These strips of "Alathon" have proved their superiority and economy and are now used exclusively by this mining company for its zinc stripping operation.



Zinc plated aluminum cathodes on stripping rack. Zinc deposits are separated from cathode by a strip of Du Pont "Alathon" polyethylene resin to simplify removal.

Du Pont "Alathon" offers a versatile set of properties for many product design uses. Can you use its lightness, flexibility, toughness and corrosion-resistance in *your* operation? Use coupon on this page for full property and application details.



Close-up of edge of cathode, showing how U-shaped strip of Du Pont "Alathon" fits tightly. Strips are extruded by Anchor Plastics Co., Inc., Long Island City, New York.

E. I. DU PONT DE NEMOURS & CO. (Inc.) POLYCHEMICALS DEPARTMENT
Room 101, Du Pont Building, Wilmington 98, Delaware.

Please send me more information on the Du Pont engineering materials checked: ☐ "Zytel"; ☐ "Alathon"; ☐ "Teflon"; ☐ "Lucite". I am interested in evaluating these materials for:

NAME _____ POSITION _____

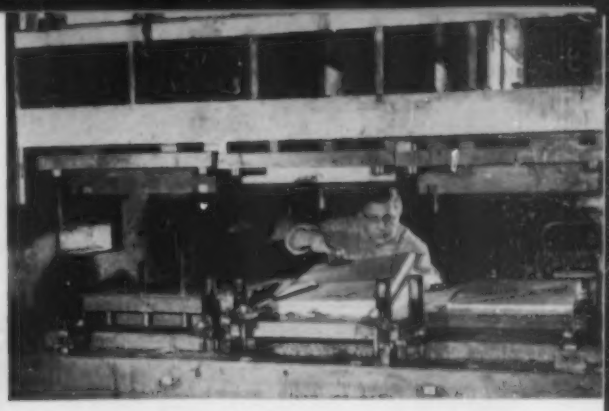
COMPANY _____

STREET _____

CITY _____ STATE _____

TYPE OF BUSINESS _____

*"Alathon", "Lucite", "Teflon" are registered trade-marks of E. I. du Pont de Nemours & Co. (Inc.)
†"Zytel" is the new trade-mark for Du Pont nylon resin.



Hydraulic press where door panels are formed. Left-hand die punches and forms; center die second-forms and trims excess metal, right-hand die final forms.

Punching and counter-sinking holes for handle and fastenings.

Strikingly beautiful **color-chrome gas range** by Magic Chef, Inc., St. Louis, Mo.

How Stainless Steel helps Magic Chef bring glamour into the kitchen

MAGIC CHEF'S new *color-chrome gas range* is an eye-catcher anywhere you see it—in the kitchen or on the sales floor. Highlighting the beautiful decorator colors of the porcelain enamel top and sides is a front of gleaming Stainless Steel.

There's real beauty here, but that's not the whole story. There's the durability of long-lasting Stainless Steel. And there's the ease with which Stainless Steel's smooth, dense surface can be cleaned—year after year.

This is the kind of sales appeal that Stainless lends to an almost countless list of products. And you can have it with surprising ease of fabrication (See "Fabricating Facts"). Put this appeal in your products, and when you do, follow the lead of successful fabricators who use service-tested USS Stainless Steel in the products they make.

FABRICATING FACTS

Compartment door, oven door and broiler drawer panels are fabricated from USS 18-8 Stainless Steel sheets, No. 3 finish.

Sheets are dry-coated with drawing compound, then sheared to blank size. Forming takes place in an hydraulic press, using three dies. Stainless Steel sheets form easily and without distortion in a die setup designed for carbon steel sheets.

Panels are paper-wrapped to protect against scratching; holes for fasteners are punched and counter-sunk. Dry-coating is removed; panels are sub-assembled and sent to the production line for final assembly.

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
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USS

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS • PIPE • TUBES • WIRE • SPECIAL SECTIONS

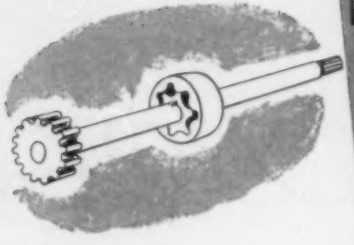
5-99

UNITED STATES STEEL

GEROTOR

will solve your hydraulic pump design problems!

Gerotor is best known for its precision built line of standard design pump models . . . BUT . . . there are many applications where special design is required. This special requirement may involve speed, capacity, limited space, mounting, weight or adaptation to some operating condition peculiar to the individual application.



For instance . . . it may be necessary to "wrap" the pump around a "thru" shaft. The unique design of the GEROTOR element (heart of all GEROTOR hydraulic pumps) permits this design feature without sacrifice of space. This is only one example of the many design problem solutions created by GEROTOR engineers.

Due to high production facilities, GEROTOR can produce special design pumps in *quantities* at an amazingly low price. Whatever your hydraulic pump design problem . . . bring it to GEROTOR.

FREE literature available . . . write:

GEROTOR MAY CORPORATION

1511 Maryland Avenue . . . Baltimore 3, Maryland

Each COR-TEN Steel container is equipped with air intake and air relief valves, and receptacles containing a desicant, which dehumidifies the trapped pressurized air to the low relative humidity that will prevent corrosion or fungus attack to the contents.

How USS COR-TEN Steel containers for military aircraft engines help save U. S. Government millions of dollars yearly

DURING the past ten years the U. S. Department of Defense has developed a new concept in the field of packaging that has vitally strengthened our military preparedness.

It consists of the use of pressurized, shock-proof steel containers for the vibration-isolated shipping, handling and storage of aircraft engines, both reciprocating and jet types.

Because these containers must be stored in air bases all over the world and are frequently transported by air, basic design requirements call for lightness coupled with high strength and corrosion resistance.

In USS COR-TEN Steel, the Baltimore Steel Company, Baltimore, Md., a producer of such containers, has found the most satisfactory material and the most economical from the cost standpoint.

By replacing carbon steel with USS COR-TEN Steel, which is 50% stronger, weight has been reduced appreciably—with no loss of container strength and at a cost comparable to mild steel. The result—a lighter, stronger finished product that has the added benefit of higher atmospheric corrosion resistance—4 to 6 times that of carbon steel. Thus the engines, shipped undamaged in these COR-TEN Steel containers, *stay* factory-new and instantly available, regardless of temperature, climate or length of storage. What's more, experience has shown that COR-TEN Steel containers are re-useable again and again with a minimum of maintenance.

As to the savings they assure, note this: The U. S. Navy reports that over a 5-month period in 1947, the loss due to corrosion and damage of engines in ordinary non-metal containers was $4,750,000. But in 1952, over a similar 5-month period, for the same number of engines in steel containers, such loss was reduced to a mere $1,750.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS COR-TEN HIGH Strength STEEL

9-71

ANNOUNCING THE NEW MAXITORQ "DISC-PAC"

A "DO-IT-YOURSELF" UNIT
FOR BUILDING YOUR OWN CLUTCH

Due to a growing demand for Maxitorq Floating Discs, we now introduce The *MAXITORQ DISC-PAC* . . . a self-contained unit independent of the actuator.

Patented Maxitorq Separator Springs that prevent drag, abrasion, and consequent heating in neutral . . . and the Maxitorq Locking Plate which locks all discs onto body . . . give you the outstanding features that are so highly favored by machine and product designers.

Thus you may build your own clutch or brake from our standard stock Maxitorq parts. The Disc-Pac keys to your shaft and is easily replaced. Units are available in 8-disc diameters from 2″ to 8″; ¼ to 15 h.p. at 100 r.p.m. . . . with 3 lugs on the smallest size, 8 lugs on the 3 h.p., and 12 lugs on the 5, 10 and 15 h.p. capacities.

The Disc-Pac fits Maxitorq standard Driving Rings in the event that you want to use them. As with the Maxitorq Clutch, all assembly, take-apart and adjustments are manual . . . no tools required.

Write Dept. PE-1 for full specifications and quotations.

1CJ84

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

THE TEETH in this drag line bucket now are fabricated from 3" sections of USS "T-1" Steel. Teeth are flame-cut, bolt holes are drilled, then teeth are water quenched and tempered to a surface hardness of 388 to 401 Brinell. No all-over machining is required, as it was previously. Flame cutting does not cause steel to crack. "T-1" cuts costs, saves time, improves performance.

How USS "T-1" Steel in Drag Line Bucket Teeth increased service life ten times

This hefty drag line is used to break and load ferromanganese which is made by the Blast Furnace Department of U.S. Steel's Duquesne Works. Ferromanganese is extremely hard and dense, so the bucket teeth must have exceptional resistance to impact abuse and abrasion.

When we bought this machine, the manufacturer used the best steel then available for the job. But still the teeth broke easily – and lasted for only 4 to 8 hours of operation. Replacement down time was frequent and expensive.

Just as an experiment, we tried our new "T-1" Steel in this rugged application. It worked beautifully. Instead of 8 hours, we are getting *80 hours* of service from each set of teeth – ten times more. Down time and replacement costs are about *a tenth* of what they used to be. Naturally we'll continue to use "T-1" Steel in this job, in the entire bucket as well as the teeth.

USS "T-1" Steel can cut costs for you in a wide variety of applications. Write for detailed facts and figures.

USE "T-1" AT HIGH TEMPERATURES. New USS "T-1" Steel has good creep rupture strength up to 900° F. It is being used in heavy-duty parts that operate at high temperatures.

USE "T-1" AT LOW TEMPERATURES. This same steel is amazingly tough at sub-zero temperatures. In pressure vessels, it has survived impacts of 2,000,000 ft. lbs. at 38 degrees below zero F. In addition, it has good resistance to impact abrasion.

USE "T-1" TO CUT FABRICATING COSTS. You have a yield strength of 90,000 psi. in "T-1" yet you can weld or flame cut this steel without pre- or post-heating. Your welds will develop the full 90,000 psi. And you can fabricate parts either in the shop or the field—wherever it is more convenient and less costly. With "T-1" Steel you can save money or improve design—sometimes both—in bridges, pressure vessels, heavy-duty trucks, excavating machines, mine cars, high speed rotating machines, steel mill equipment, and stamping and forging presses.

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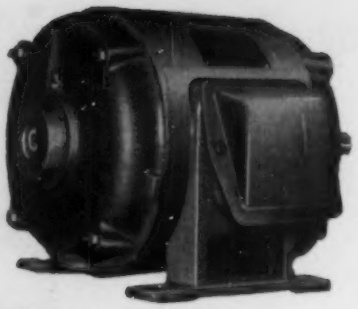
USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

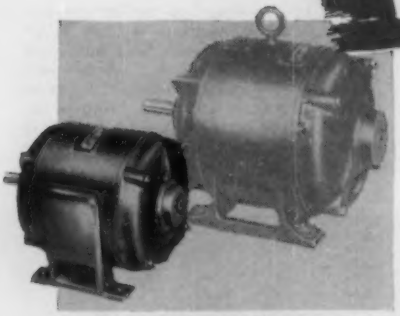
5-203

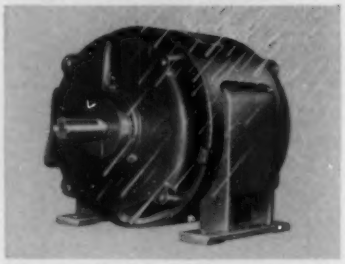
NEW Century Performance-Rated® INTEGRAL H.P. MOTORS

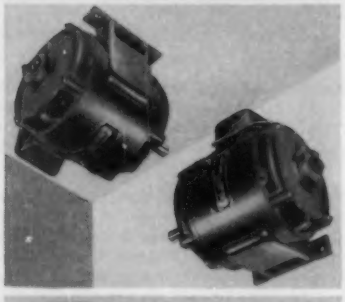


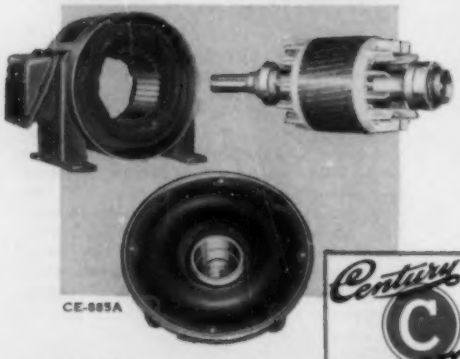
Now available in
1 . . . 1½ . . . 2 H.P. sizes—
NEMA frames 182 and 184.

Improved Motors to match your needs









CE-885A

SMALLER — LIGHTER

More uniform silicon-laminated steel; thinner, *tougher* "Mylar" slot insulation — just two of the many technical developments that help make these new Century Performance Rated Motors so much *smaller* and *lighter*.

BETTER PROTECTION

New concepts of internal motor ventilation permit end bracket and frame design that gives far better protection from falling liquids and solids . . . still maintain 40°C. temperature rise.

MORE FLEXIBLE MOUNTING

You can even have cushion mounting with these new Century Integral H.P. Motors — your choice of sleeve or ball bearings. Ball bearing motors mount vertically, upside down, in any position. End brackets can be rotated for floor, ceiling or side wall mounting.

EVEN MORE DEPENDABILITY

Improved plastic impregnating varnish and plastic insulated magnet wire provide unusual resistance to abrasion, moisture and heat. These new materials possess far better dielectric qualities. Die cast aluminum rotors are individually, dynamically balanced to assure freedom from vibration.

Call Your Century Application Engineer...

Ask him about the new Century Performance Rated Integral and Fractional H.P. Motors.

Century C MOTORS

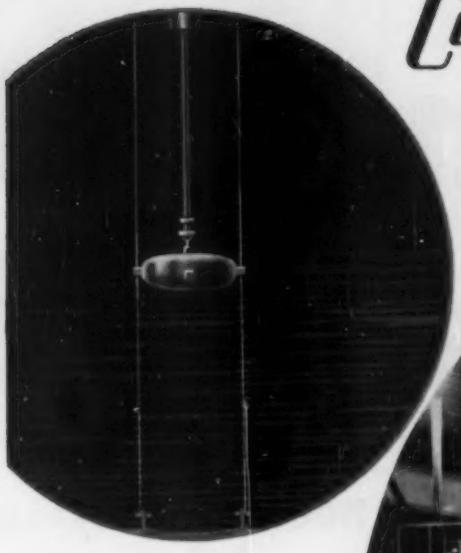
Offices and Stock Points in Principal Cities

CENTURY ELECTRIC COMPANY • 1806 Pine Street • St. Louis 3, Missouri

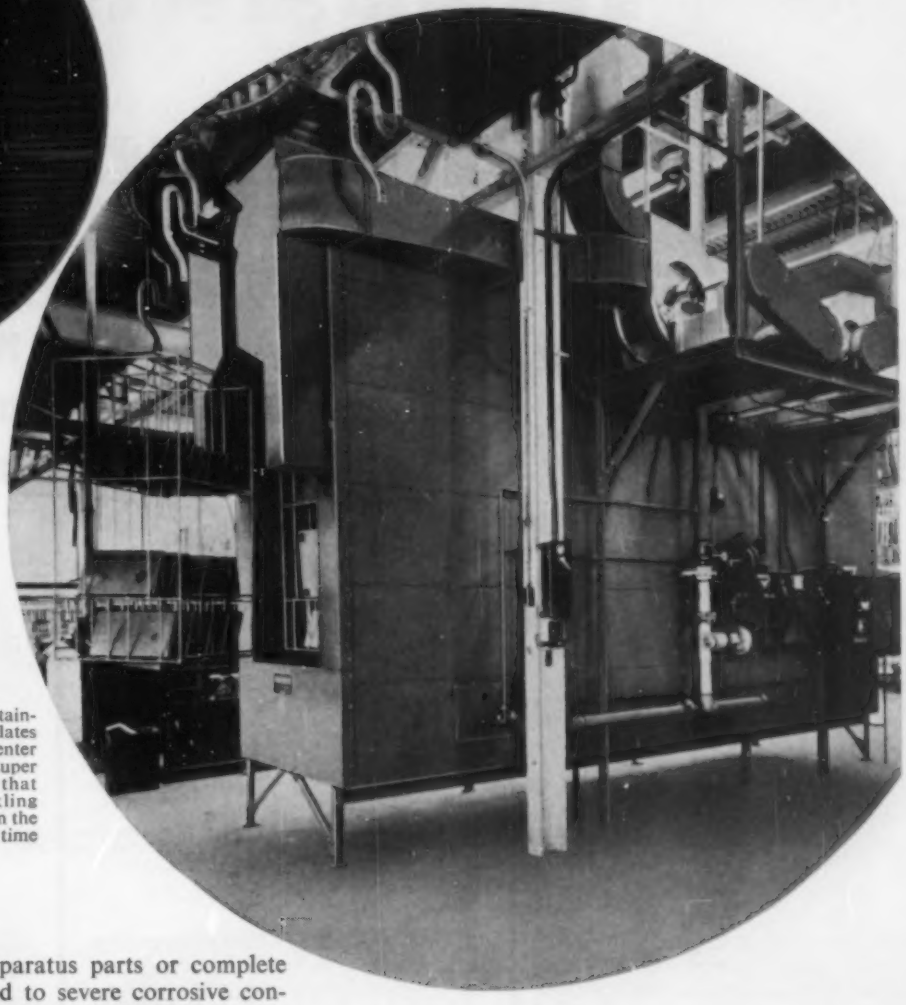
In Small Parts or Large...

Carpenter Stainless No. 20

Controls STRONG Corrodents



SMALL—This diagram shows float and attached steel indicator strip of an automatic gauge used in sulphuric acid storage tanks. These parts are made from Carpenter Stainless No. 20 and No. 20Cb for longer life.



LARGE—Carpenter Stainless No. 20Cb sheet, plates and tubing, and Carpenter No. 20 bars provide super corrosion resistance that keeps huge acid-pickling machines like this one on the job, saves maintenance time and expense.

Wherever you have small apparatus parts or complete large-scale equipment subjected to severe corrosive conditions, you can build extra service life into them with Carpenter Stainless No. 20 and No. 20Cb.

This super stainless alloy is highly resistant to H_2SO_4 concentrations or solutions, as well as a long list of other strong corrodents. So build with Carpenter Stainless No. 20 and No. 20Cb for greater freedom from corrosion troubles, extended equipment life, less down-time for replacements, and greatly reduced corrosion control costs.

This time-saving, cost-cutting super corrosion-resistant Carpenter stainless alloy is available in the form of No. 20Cb tubing, pipe, sheet and plate, as well as No. 20 bar, wire, strip, and billets. Ask your nearest Carpenter distributor or sales office for assistance on your corrosion problems . . . and a copy of the NEW Carpenter Stainless No. 20 and No. 20Cb handbook.

MEMBER

The Carpenter Steel Company,
Alloy Tube Division, Union, N. J.

Export Dept., The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

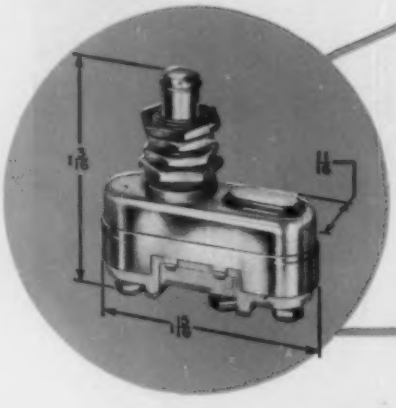
Stainless Tubing & Pipe

For information on Carpenter Stainless No. 20 strip, wire, billets, contact The Carpenter Steel Company, Reading, Pa.

MICRO SWITCH Precision Switches
A PRINCIPLE OF GOOD DESIGN

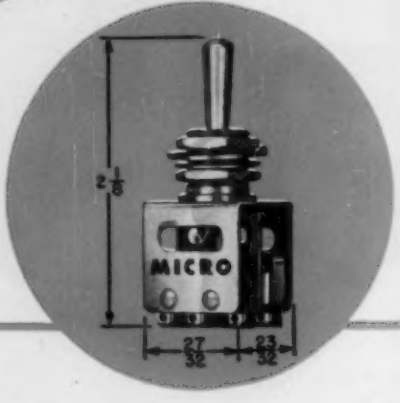
There's that can meet requirement!

need a high temperature switch?



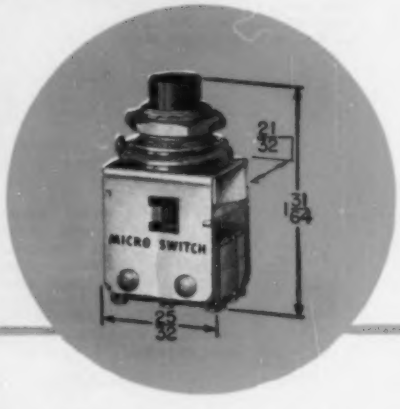
Does your design call for a switch that will operate perfectly at 1000°F? Originally designed to withstand the terrific heat of jet engines, this switch has met some very exacting requirements for a precision switch to operate in high temperatures. It has been found useful in equipment designed for distilleries, foundries, vulcanizing plants or other industries requiring high temperature components. For complete information and consultation on MICRO SWITCH precision switches contact your nearest branch office.

need a toggle switch assembly?



Many variations of these extremely small toggle switch assemblies are available for the control of multiple circuits. Shown is such an assembly for panel mounting which uses two SPDT subminiature switches to control up to 4 circuits. The small size of this switch permits mounting in minimum space behind panel. Other toggle switch assemblies are available which permit control of up to 16 circuits. If THE switch you need must do a big job in a small space check with MICRO SWITCH.

need a push button assembly?

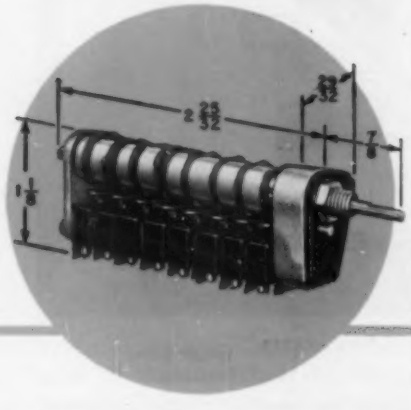


This is a subminiature push button switch assembly for two-circuit control. This switch provides an improved "feel" and simultaneous make and break of the two circuits. Other push button assemblies include one for panel mounting with the plunger mechanism sealed at the panel; also slide button assemblies where two subminiature switches are mounted in a three position, maintained contact assembly. Whatever your switch requirement it will pay you to contact MICRO SWITCH.

A complete line of precision snap-action and mercury switches

Only 1 Switch
Your specific

need a subminiature rotary assembly?



Perhaps you need a small subminiature rotary selector switch. Here's one that will control from 2 to 16 circuits. It uses from 2 to 8 SPDT subminiature switches and permits from 2 to 8 switching positions with spring or manual return to neutral position.

Whatever the one switch you need to improve the performance of your design, there is—or can be—a MICRO SWITCH product to meet your requirement *exactly*. Call MICRO SWITCH today. It may save you time and money.

Let MICRO SWITCH Engineering Service help you select it!

Call your nearest MICRO SWITCH branch office today

MICRO SWITCH provides a complete line of extremely reliable, small-size, high-capacity, snap-action precision switches and mercury switches. Available in a wide variety of sizes, shapes, weights, actuators and electrical characteristics. For all types of electrical controls.

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In Canada, Leaside, Toronto 17, Ontario · FREEPORT, ILLINOIS

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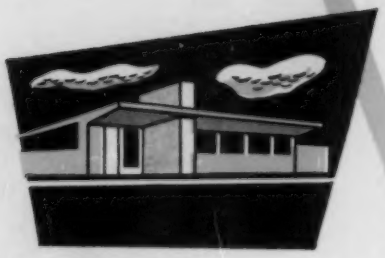
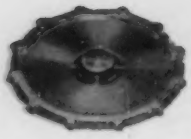
ARE MADE TO LAST!

QUALITY PARTS AND PRODUCTS FORGED AND MACHINED OF BRASS, BRONZE AND ALUMINUM OR MAGNESIUM



IN THE HOME



IMPELLER DISPOSER

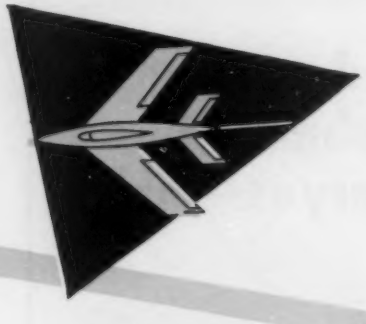
One of four Mueller Brass Co. parts in modern waste disposal unit. Completely dependable in daily operation.

WINDOW HARDWARE

Forged of natural bronze. Can be furnished in aluminum or chrome finish as desired. Retains original beauty indefinitely.

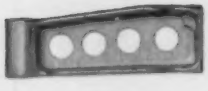
BURNER HEAD

Forged of aluminum for installation in gas stove. Lightweight yet strong.



IN AVIATION

LANDING GEAR TORQUE ARM



SUPPORT MEMBER

INSTRUMENT HOUSING

These aluminum forgings provide the same strength as steel yet weigh only 1/3 as much. Smooth bright surfaces save machining time and eliminate costly finishing.

Specially designed forged housing for sealing diaphragm in aviation pressure warning unit.

IN INDUSTRY

CONNECTING ROD

Forged from "600" series metal. Over two million connecting rods produced without recorded failure.

ACTUATING GEAR

Forged from special Mueller Brass Co. alloy. Must take constant pounding.

AUTOMOTIVE GEAR

Forged of "600" series metal for use in automotive automatic transmission. Replaced part that was giving constant trouble; solved costly problem.

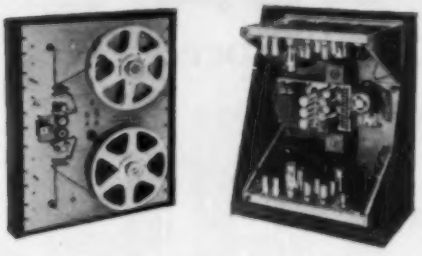
All Mueller Brass Co. forgings, of which just a few are shown here, have a dense, close-grained structure with a high tensile strength. Weight savings up to 40% are possible in the design of parts because of the close tolerances to which they can be produced. Less scrap and longer tool life result from the easy machinability of forged parts. Mueller Brass Co. is completely equipped to design parts for your products, specify alloys (including special alloys developed by our metallurgists), forge, machine, finish and plate the parts and perform all necessary assembly operations. Write today for our free illustrated 32-page forgings catalog and complete information about MBCo forged parts for your products.

140

MUELLER BRASS CO. PORT HURON 17, MICHIGAN

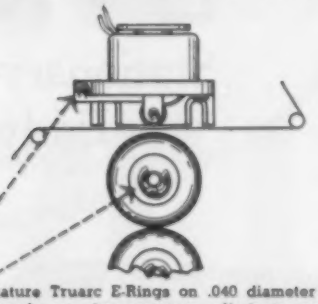
30 Waldes Truarc Rings Save Space and Time... Simplify Assembly and Disassembly

Potter's New Digital Magnetic Tape Handler



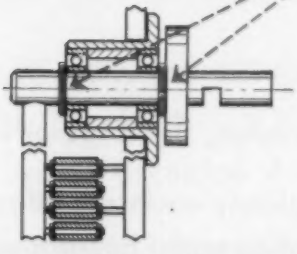
■ Prime requirements: fast starts, fast stops, fast tape speeds, great accuracy. Using Truarc rings, this new model starts and stops the tape within 5 milliseconds, has tape speeds up to 60 inches per second.

Solenoid Mount and Capstan Assembly



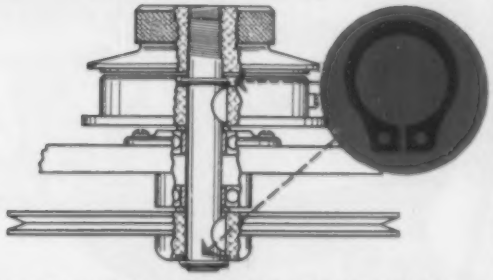
■ Miniature Truarc E-Rings on .040 diameter shaft and on continuously running capstans eliminate projecting bolts and screws. Rings permit rapid assembly and disassembly, fast replacement of worn rubber capstans.

Tension Shaft Assembly



■ Truarc E-Rings snap quickly into place, act as shoulders for the ball bearings with a minimum of friction. Additional Truarc Rings are used as spacers on shafts, can be located accurately to extremely close tolerances.

Reel Shaft Assembly



■ Truarc Standard Rings (Series 5100) hold the reel shaft assembly firmly in place and permit the use of quick-lock hubs so that the reel tapes can be changed in seconds as they are finished.

Potter Instrument Company, Inc., of Great Neck, L. I., uses 30 Waldes Truarc Retaining Rings in their new Model 902 High Speed Digital Magnetic Tape Handler. In addition to solving a variety of fastening problems, Truarc Rings facilitate the rapid acceleration and fast stopping needed in these machines.

Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better, more economical job. Truarc Rings are precision engineered, quick and easy to assemble and disassemble. They save time and increase operating efficiency.

Find out what Waldes Truarc Retaining Rings can do for you, toward saving costs and improving your product. Send your blueprints to Waldes Truarc Engineers for individual attention without obligation.

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TRUARC

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WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,392,949; 2,410,052; 2,420,021; 2,420,241; 2,420,785; 2,441,640; 2,458,160; 2,483,300; 2,483,393; 2,487,902; 2,487,903; 2,491,305; 2,500,081 AND OTHER PATENTS PENDING

For precision internal grooving and undercutting . . . Waldes Truarc Grooving Tool!

PN017

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(Please print)

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Title .....

Company .....

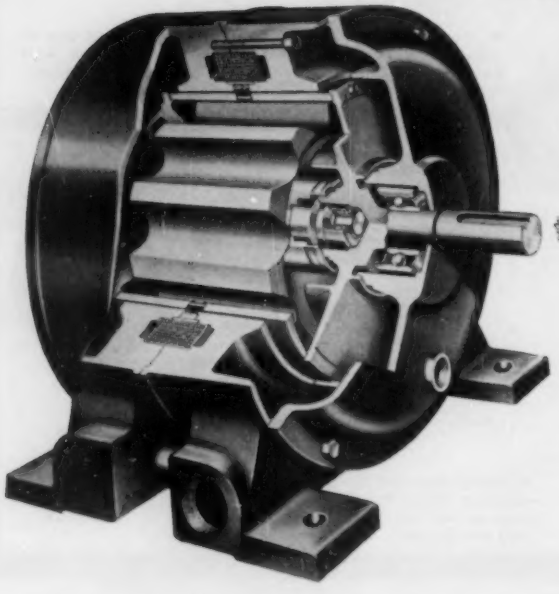
Business Address .....

City ..... *Zone* ..... *State* .....

Introducing the New

DYNASPEDE®

Stationary-Field Adjustable Speed Eddy-Current Coupling



★ No brushes, slip rings, or commutator.

★ Completely enclosed; adaptable for operation under hazardous conditions.

★ Wide-range stepless speed control.

★ Reduced maintenance.

Augmenting the well recognized and widely used Dynamatic line of eddy-current couplings, brakes, and drives, the new DYNASPEDE Liquid Cooled Stationary-Field Coupling offers a number of outstanding design and operational advantages.

Principal design features include the mounting of the field section integral with the coupling frame, with the drum-ring rotating concentrically with the field. A toothed rotor (the output member) is mounted concentrically with the drum.

The absence of slip rings and brushes eliminates the possibility of arcing, and adapts DYNASPEDE to hazardous applications in explosive or corrosive atmospheres. Maintenance is materially reduced.

The torque characteristics of the DYNASPEDE coupling are such that with uniform excitation, the torque curve continues to rise with increased slip.

As is the case with all Dynamatic eddy-current couplings, DYNASPEDE provides a very wide range of stepless speed control.

Send for Illustrated Descriptive Literature

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DIVISION EATON MANUFACTURING COMPANY

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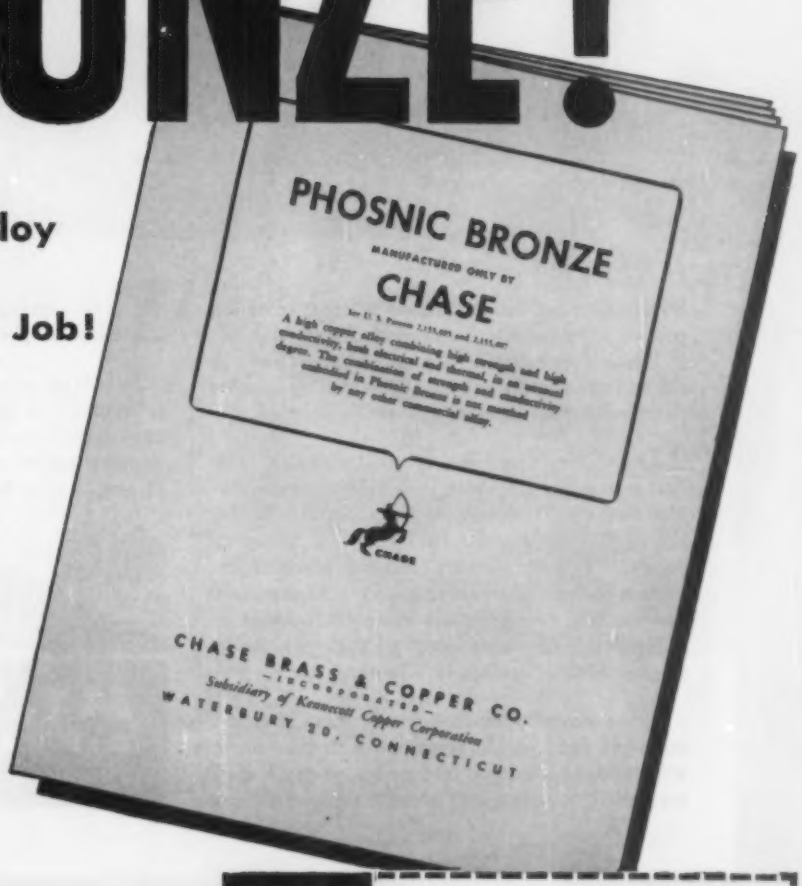
For jobs requiring a metal with high strength as well as high conductivity, Chase Phosnic Bronze is ideal.

The combination of high strength and high conductivity found in Chase Phosnic Bronze *is not matched by any other commercial metal!* In addition, Chase Phosnic Bronze has excellent workability, high corrosion resistance.

For complete information on this special Chase alloy, check the coupon below.



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Die Casting

enables **1** maker
to use the same **2** parts
for **3** different tools

CASE HISTORIES FROM MT. VERNON FILES

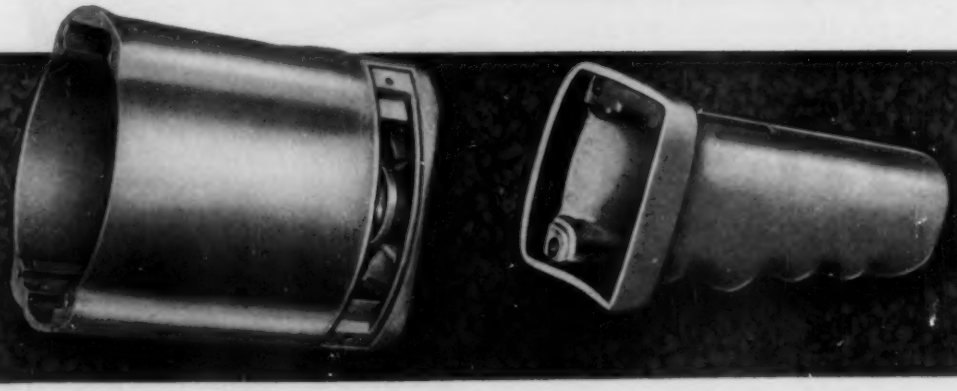
While we have introduced the economies of die casting to manufacturers in many fields, it strikes us that Millers Falls Co., Greenfield, Mass., comes closer than most to gaining the *maximum* benefits from making die cast parts interchangeable.

Among the varied line of quality electric tools they make are the three units shown above: (A) The No. 404 Portable Electric Grinder; (B) The No. 270 Polisher; (C) The No. 870 Industrial Sander. In each of these tools two identical Mt. Vernon die cast parts serve as motor housing and handle. The two parts are fastened together at different angles—but think of the savings in labor, savings in time, savings in inventory!

Other advantages inherent in these die-cast parts are light weight combined with strength to withstand the vibration and pounding these tools receive—also, even with intricate designs such as these, die casting is done to such close tolerances that machining is minimized.

Whatever *your* product, you can almost certainly profit by considering the advantages of die casting: light weight, simplicity, lower costs. Our varied experience of many years is wholly at your service. Let us know your needs today.

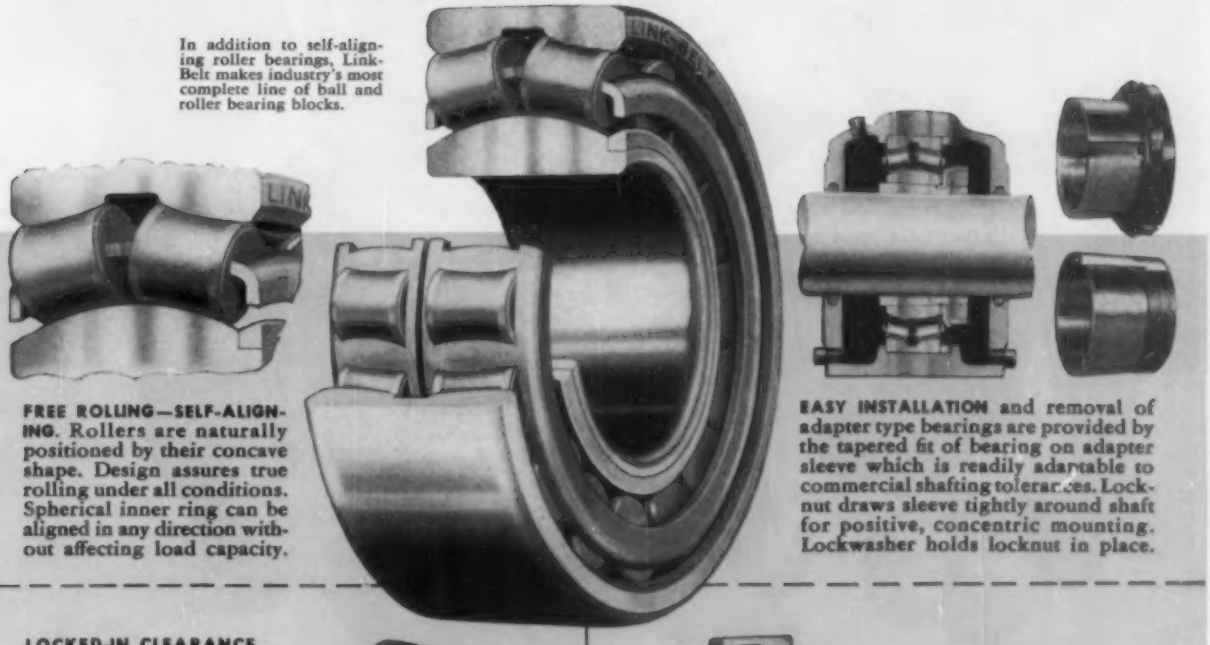
MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT



For tough, heavy-duty applications... Make use of these important

bearing differences

In addition to self-aligning roller bearings, Link-Belt makes industry's most complete line of ball and roller bearing blocks.

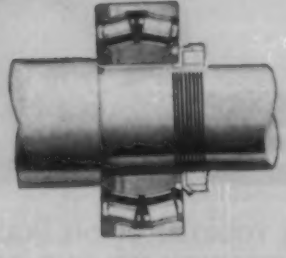


FREE ROLLING—SELF-ALIGNING. Rollers are naturally positioned by their concave shape. Design assures true rolling under all conditions. Spherical inner ring can be aligned in any direction without affecting load capacity.

EASY INSTALLATION and removal of adapter type bearings are provided by the tapered fit of bearing on adapter sleeve which is readily adaptable to commercial shafting tolerances. Locknut draws sleeve tightly around shaft for positive, concentric mounting. Lockwasher holds locknut in place.

LOCKED-IN CLEARANCE. Selective assembly of rollers and raceways with accurately formed hardened steel retainers assures proper operating clearance, guidance and spacing of rollers.

Rollers are completely pocketed in retainers for accurate spacing and guiding.



SMOOTH OPERATION, LONG LIFE are advantages of the straight bore type mounting, which assures maximum concentricity of inner ring with shaft. Especially desirable when minimum radial run-out is essential.

They're all present only in LINK-BELT self-aligning roller bearings

SUBTLE differences in bearings can make notable differences in the life and efficiency of your equipment. Take Link-Belt self-aligning roller bearings, for example. Their "self-contained" feature permits the bearing to float axially in the mounting, when desired, compensating for shaft expansion or settling of bearing supports . . . preventing extraneous thrust loads from being set up between bearings on the same shaft. What's more, inherent self-aligning design and preadjustment preclude use of expensive or cumbersome self-aligning housings.

Ask your nearest Link-Belt office for Book 2196 on self-aligning roller bearings and Book 2550, containing full data on all Link-Belt ball and roller bearings.

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 10,711

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★ **A utility company selected "U. S." molded rubber cable joints because "U. S." could fabricate an entirely *uniform* wall thickness in an extremely complex design. The high dielectric resistant compound provides top safety.**

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Use WELDED STEEL for Greater Strength with Less Weight!

Steel-Weld Fabricated parts and assemblies can save you time and money in many ways . . . they eliminate pattern costs and give you greater strength with less weight. The parts and assemblies shown at the left, and the forty-ton frame and carriage shown above—parts of a loading device for a large extrusion press—are typical examples of thousands of Steel-Weld Fabricated units produced and machined by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. If you need a special mechanical device, or if you require parts or assemblies involving large heavy pieces where time and pattern costs are a consideration, you can call on Mahon with complete confidence . . . personnel and facilities are available within the Mahon plant to handle the entire job from drawing board to finished machining and assembly. You will find in the Mahon organization a unique source . . . a source where design skill and advanced fabricating technique are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon engineer call at your convenience.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

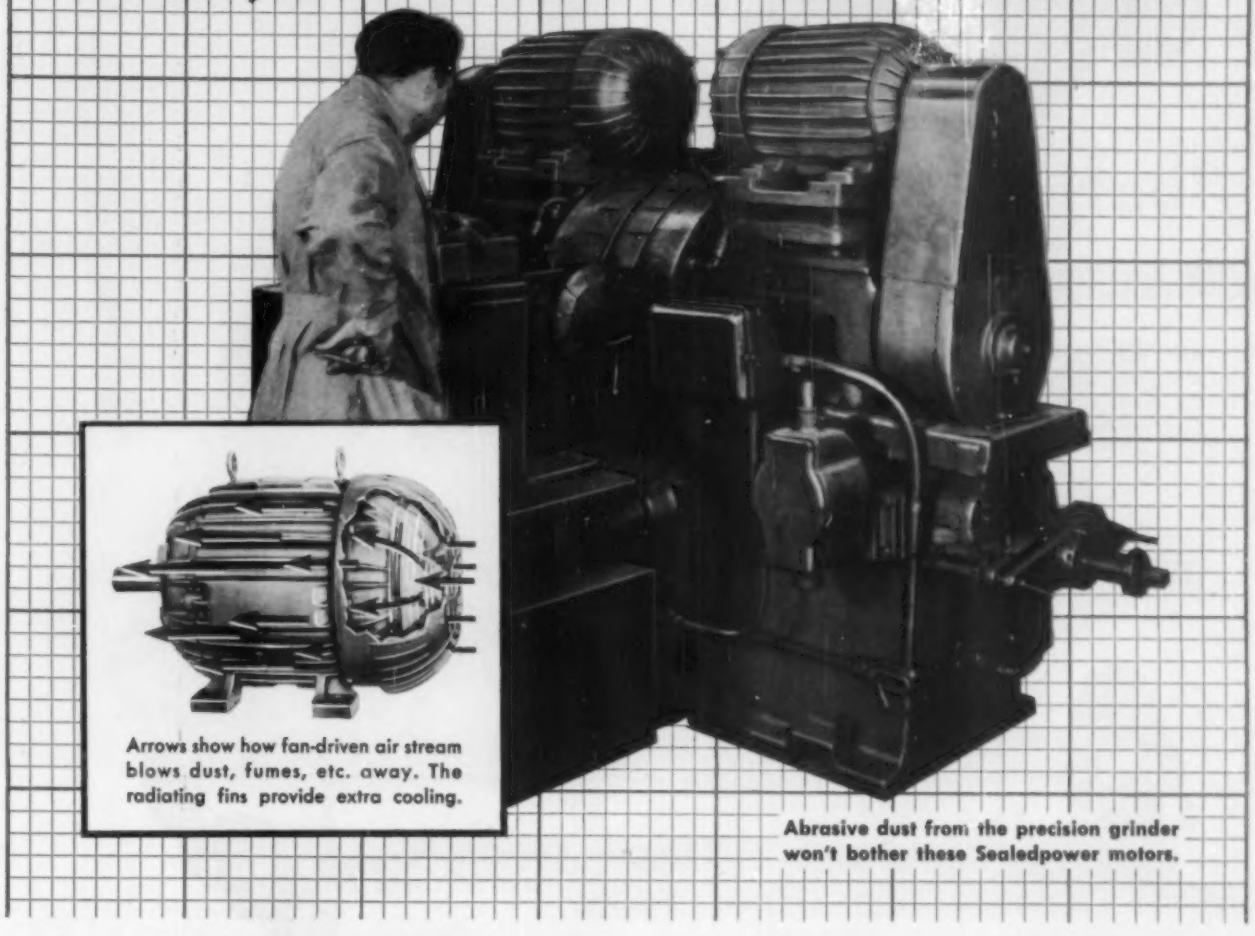
MAHON

for tubing
that can take it—
and can take
any shape

Remember
GM STEEL TUBING
By Rochester Products

GM STEEL TUBING BY ROCHESTER PRODUCTS, DIVISION OF GENERAL MOTORS, ROCHESTER, N.Y.

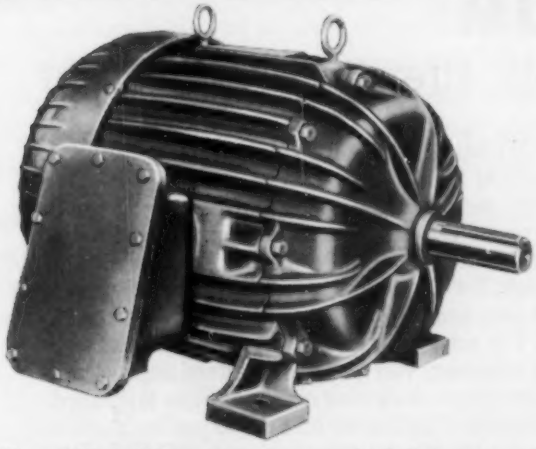
IF DUST, DIRT OR FUMES ARE IN THE PICTURE...



Arrows show how fan-driven air stream blows dust, fumes, etc. away. The radiating fins provide extra cooling.

Abrasive dust from the precision grinder won't bother these Sealedpower motors.

Specify ELLIOTT C-W Sealedpower Motors

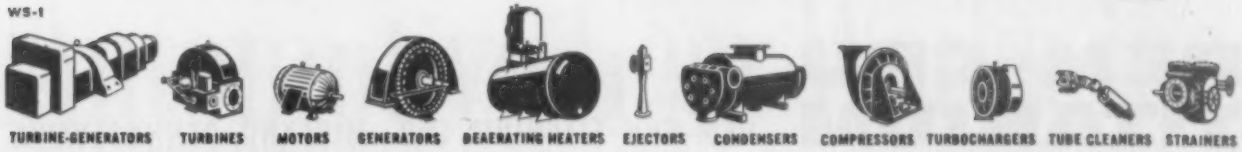


Elliott C-W Sealedpower motors are also built in approved explosion-proof design for hazardous locations.

These totally-enclosed, fan-cooled motors insure your machines against failure, production time losses and costly maintenance in dirty, exposed areas. A steady stream of cool fan-driven air keeps dust from settling on the frame and drives off the heat radiated from the finned motor casing. For extra protection, Sealedpower motors are effectively sealed against liquid penetration. Wide range of modifications such as with gear or brake, explosion-proof enclosures. Sizes 1 to 100 hp, NEMA frames. Full details in Sealedpower Motor Bulletin. Write Elliott Company, Crocker-Wheeler Division, Jeannette, Pa. for your copy.

ELLIOTT Company

WS-1



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REM-CRU C-130AM titanium alloy forgings, produced by the Steel Improvement & Forge Co., Cleveland, Ohio.

Now—design with

REM-CRU TITANIUM

for corrosion resistance—high strength—light weight

Greatly expanded facilities make REM-CRU titanium available for nondefense applications. Now get *prompt* delivery of REM-CRU titanium in bars, plates, sheet, strip, wire, tubing and forgings . . . in a wide range of sizes, shapes, grades . . . including the high-strength, weldable alloy, REM-CRU A-110AT.

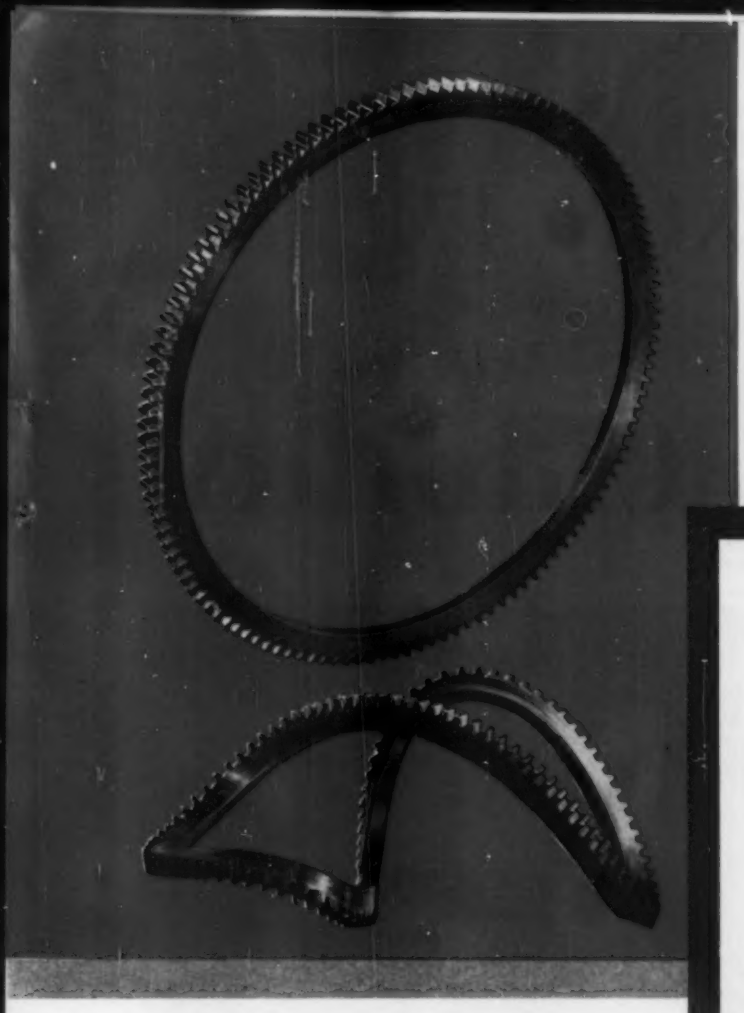
Forgings of REM-CRU titanium, like these illustrated, have light weight and high strength, plus exceptional resistance to most forms of corrosion. These forgings are designed to withstand very rugged service involving impact shock, vibration and stress.

REM-CRU titanium can be machined, formed from sheet, and welded—it is a *practical* metal for an unlimited number of applications. Condenser and heat exchanger units, evaporators, autoclaves, tubing, valves and fittings, for example, can all be profitably made of titanium.

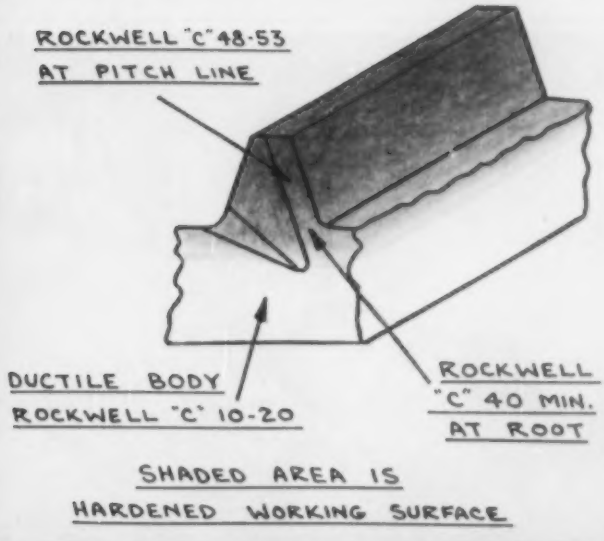
The advantages of REM-CRU titanium are so superior, you just can't afford to overlook them when designing new products. For down-to-earth suggestions on how to make the most profitable use of titanium, call a REM-CRU engineer *now*.

REM-CRU TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA



THIN! TOUGH! ...and "tender-hearted"



THE MANUFACTURE of flywheel ring gears poses special problems. Sectional thickness is usually less than three-quarters of an inch. To withstand the impact force of the starter pinion, the gear teeth must be hard. But the gear body itself should be unhardened so that it will conform tightly to the flywheel, and "give" under the stress that might snap a brittle gear.

Note how DOUBLE DIAMONDS are made to be thin, tough, "tender-hearted." The above photo of a gear twisted into a pretzel shape graphically demonstrates ductility. The sketch at right shows three important areas: the wide and deep hardness pattern, the generous area of transition, and the ductile body. These extremes are achieved in DOUBLE DIAMOND Flywheel Ring Gears by controlled selective heat treatment—all essential to flywheel ring gears that provide the best possible performance.

Our Engineering Department will be glad to make constructive suggestions on the design of flywheel ring gears, or on the many other types in which we specialize. Write, phone or wire—depending on the urgency of your need.

DOUBLE DIAMOND GEARS

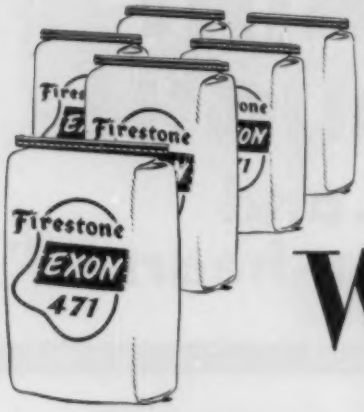
FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914

RICHMOND, INDIANA

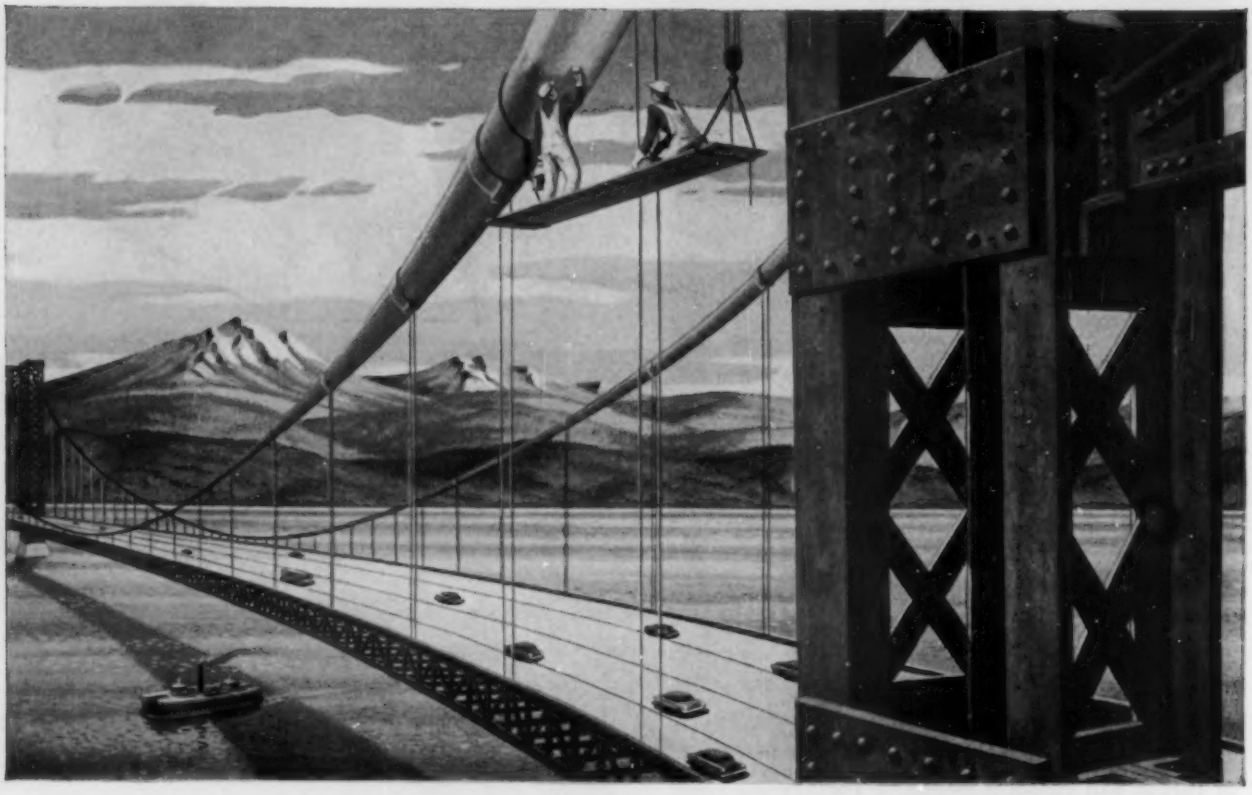
EXON: a specific remedy for each specific problem



EXON 471

specifically for

weatherability



Unmatched for outdoor durability by other vinyl solution resins, EXON 471 assures protective coatings with superior weathering and aging qualities—*plus* chemical resistance.

After a full year of outdoor exposure, a coating of EXON 471 clear glossy film revealed no measurable change. Other vinyl copolymer coatings similarly exposed deteriorated in 3 months.

Under sun lamp exposure for 360 hours as a one mil film, EXON 471 showed no noticeable change!

2-hour bakings in a 180-degree forced-air oven left no sign of yellowing on a film of EXON 471!

Proven durability and adhesion to wash primers make EXON 471 the ideal resin for better protection and longer life in a topcoat.

Whatever your particular problem, you're likely to find the specific remedy in one of the many versatile EXON resins.

For complete information or technical service on the entire line of EXON *resins, call or write today.*

Firestone

EXON

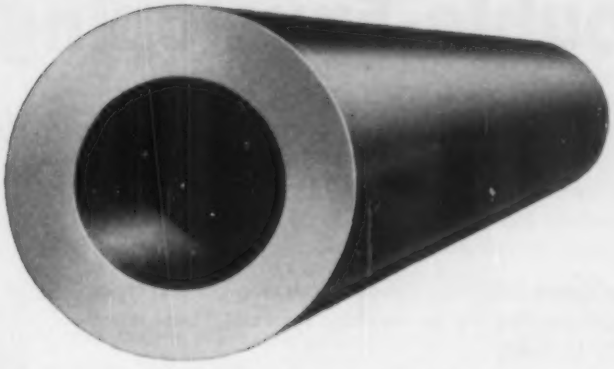
CHEMICAL SALES DIVISION

FIRESTONE PLASTICS COMPANY, POTTSTOWN, PA., DEPT. 6J

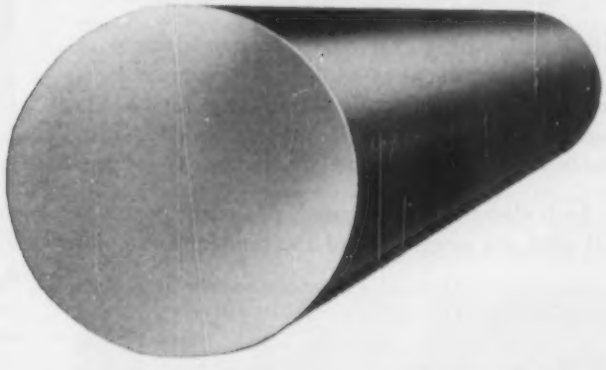
DIVISION OF FIRESTONE TIRE & RUBBER CO.

When you make hollow parts . . .

Start with seamless tubing



instead of bar stock



Save steel, machining time!

WHEN you make hollow parts from bar stock, you waste time boring the center hole—you waste steel because you have to throw away the chips you bore out. Why not do it the easy, economical way? Start with Timken® seamless tubing. The hole's already there! Finish boring is often the first production step. You cut machining time—get more parts per ton of steel.

With Timken seamless tubing, your machine tools are more productive. Screw machine stations normally used for drilling can be released for other jobs. You get added machine capacity without additional machines.

To make sure you save even *more* steel, our engineers will study your problem and recommend the most economical tube size for your hollow parts job, guaranteed to clean up to finish dimensions.

You also get the highest internal quality with Timken seamless tubing. The piercing process by which it's made is basically a forging process. Result: a uniform spiral grain flow for greater strength and a refined grain structure which brings out the best quality of the metal. And the Timken Company's rigid control keeps the quality uniform from tube to tube and heat to heat. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Design for Efficiency with Double-Enveloping Worm Gearing

Reduce size and cost of your drive systems by utilizing this outstanding method of power transmission

Designers today can choose from two general types of worm gearing for use in drive systems. These types (Fig. 1) include:

1. Gearing with one element throated.
2. Gearing with both elements throated.

In cylindrical worm gearing, only one element is throated. Contact between teeth is a theoretical line, varying in length with tooth design. One member is involute in form, the other straight-sided. Under load, the line contact widens to a thin band or zone of contact.

When both elements are throated, or double enveloping, all teeth are straight-sided and tangent to a common circle, and in contact the full depth of the teeth. As a result, we have line contact across the face plus a line contact extending full depth of the teeth. The resulting area contact occurs on all teeth in mesh, giving multiple-tooth area-contact. Basically, this means higher load-carrying capacity than possible with other types of gearing.

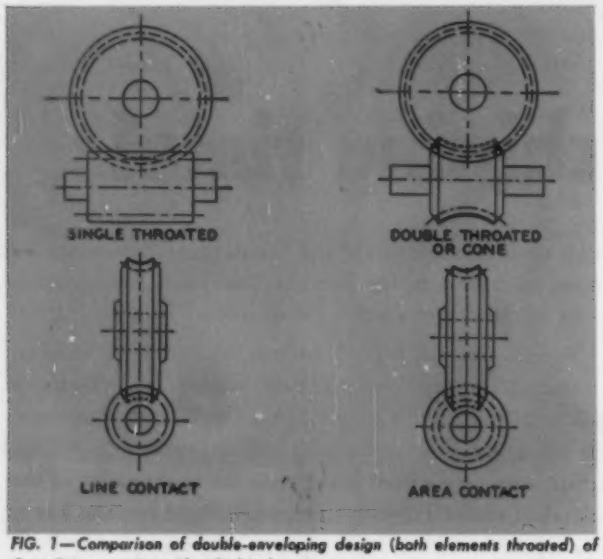


FIG. 1—Comparison of double-enveloping design (both elements throated) of Cone-Drive gearing with cylindrical worm gearing.

We call these double-enveloping worm gears "Cone-Drive" gears. They possess another feature possible only with the double-enveloping design—the ability to regenerate or reproduce themselves when wear occurs.

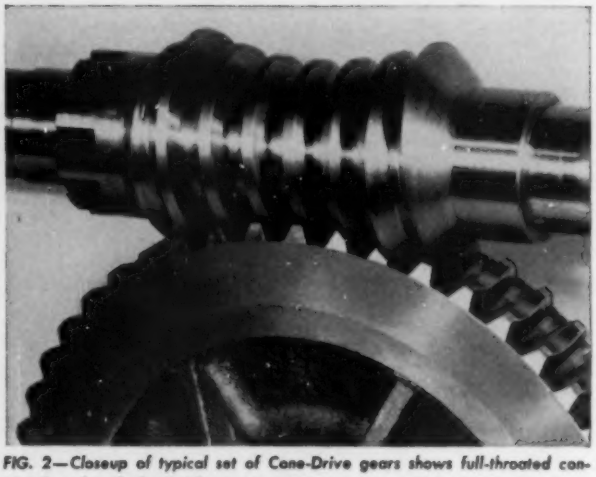


FIG. 2—Closeup of typical set of Cone-Drive gears shows full-throated construction of each element for area contact.

With Cone-Drive gears, total contact area and combined tooth strength have the same values for any given center distance regardless of the ratio used. For any given center distance, the smaller the number of teeth the larger each individual tooth and vice-versa.

The number of teeth in contact is always ⅛ of the total on the gear. If there are 48 teeth on the gear, 6 will be in engagement at all times. Reduce the teeth to 24 and there will be 3 in engagement—but each tooth will be twice as large.

What does this double-enveloping or wrapping of one gear around the other mean to the designer?

COMPACT BUT POWERFUL

By spreading the load over a greater contact area, Cone-Drive gears reduce unit pressures. Gearsets can have much smaller center distances—carry loads that require cylindrical gearing that is much larger and heavier (up to three times as much.) This also means that housings can be smaller, weight reduced and the product made more compact.

It is often possible to replace large, bulky gear trains with standard Cone-Drive gears because of their ability to handle large loads with high reductions on small center distances. Again the result is increased compactness and, very often, much lower cost for a better product.

AVAILABLE IN MANY SIZES, RATIOS AND TYPES

Cone-Drive gears are available in many forms. These include:

1. **Gearsets (444 standardized sets)**
2. **Speed reducers (over 190,000 standardized models)**
   - **Standard.....shaft over, under or vertical**
   - **Shaft-mounted.....shaft over, under or vertical**
   - **Fan-cooled.....shaft over, under or vertical**
   - **Double-reduction.....shaft over, under or vertical**
   - **Motorized.....shaft over, under or vertical**
3. **Ratios from 5:1 to 4900:1**
4. **Loads from fractional to 800 hp**

All parts for a given center distance—gears, mountings, bearings, housings, fan-cooling attachments and water cooling coils (for continuous high-load operation), etc.—are standardized whether you require pinion under or over, gear shaft vertical or horizontal, single or double-extended shafts, right or left hand.

SMOOTH OPERATION FEATURED

Cone-Drive gears provide power transmission as smooth or smoother than the finest hydraulic system. The large number of teeth in continuous contact are responsible for this feature. When desired, these gears can be made "self-locking" so that no movement takes place in either direction of rotation of the gear unless power is applied to the worm.

With a tooth shape that gives maximum strength where needed plus full-depth engagement, Cone-Drive gears resistance to shock loads is remarkable. Ratings for continuous shock load service are high. Maintenance consists primarily of proper lubrication. The regenerating or "wearing-in" feature also adds greatly to life.

ASSEMBLY NO PROBLEM

A question is sometimes raised, because of the double-enveloping design, as to the accuracy to which the end position of the Cone-Drive pinion must be held in assembly. This accuracy is directly related to the size of the gear set. The average gear is approximately 4 times the size of the pinion. Thus, accuracy of end location of the pinion is only ¼th as critical as the side position of the gear. Accuracy required for side position and center distance of Cone-Drive gears is the same as for cylindrical worm gearing. When side position location of the gear is provided for as in all worm gears, the additional dimension providing end position location of the worm requires only ¼th the accuracy. For instance, the lead of a 6" center distance worm changes only 0.0007 in. for an end movement of the worm of 0.010 inch.

ADD SALES APPEAL

Industry and its customers have steadily come to recognize the many advantages of Cone-Drive gearing in the products they buy. Many manufacturers today give prominence to their use of Cone-Drive gears in product literature and advertising, taking advantage of their inherent sales appeal and desirability.

Whether you want gearsets for built-in application, standard single-reduction speed reducers, double-reduction reducers, shaft-mounted reducers, motorized reducers, or fan or water-cooled reducers, Cone-Drive Gears has them in stock. All parts are available from stock if you should ever need them. All bearings are standard, too.

Ask for Bulletin 789-54 for additional information.

CONE-DRIVE GEARS
Division Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

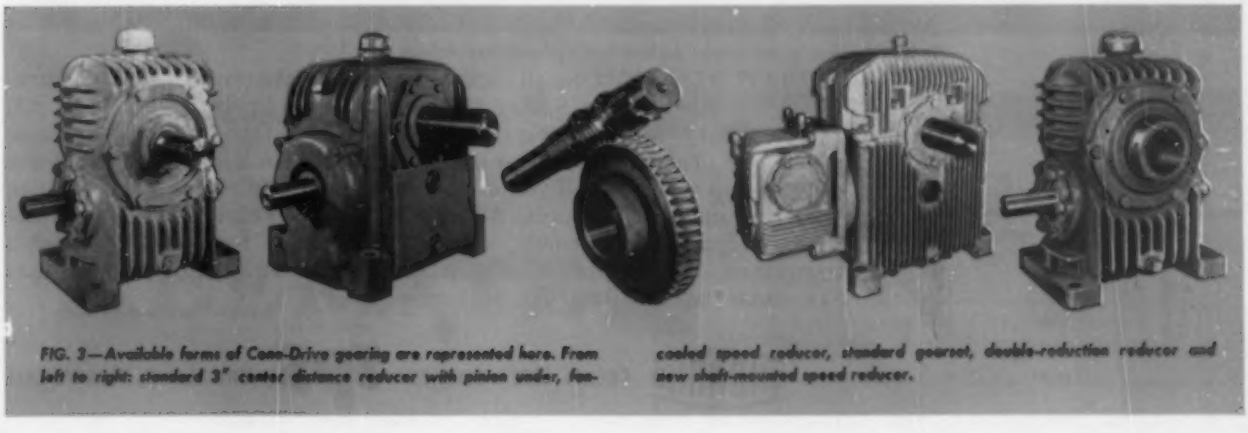
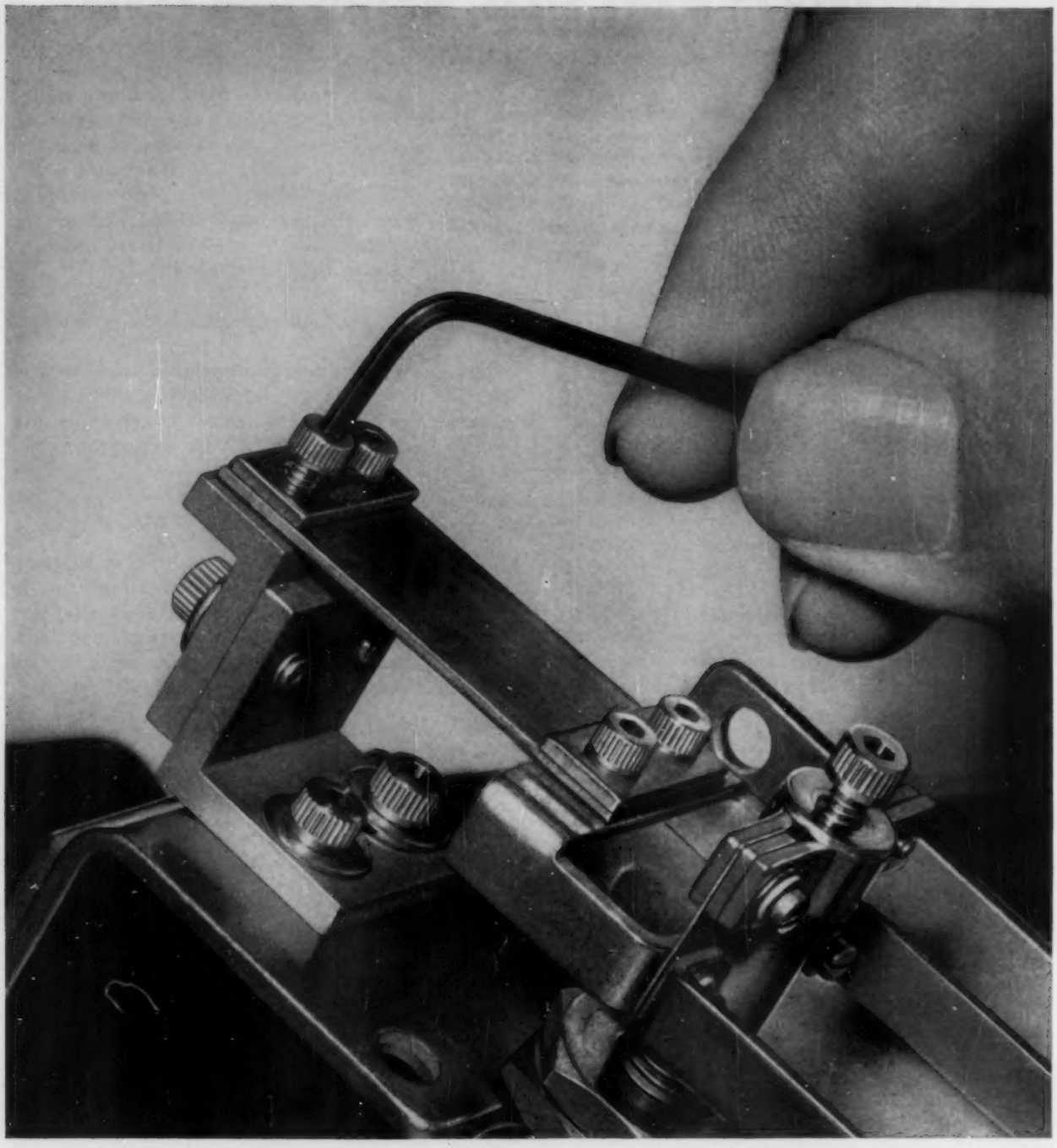
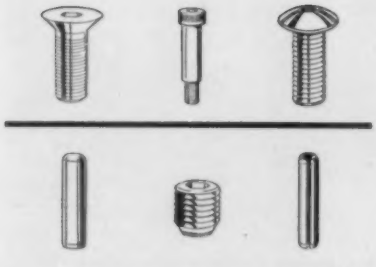


FIG. 3—Available forms of Cone-Drive gearing are represented here. From left to right: standard 3" center distance reducer with pinion under, fan-cooled speed reducer, standard gearset, double-reduction reducer and new shaft-mounted speed reducer.

UNBRAKO AT WORK





MINIATURIZATION. Small socket cap screws make possible smaller instruments. UNBRAKO Micro Socket Cap Screws range in size from #0 to #3, from ⅛" to ½" in length. But they have much more than microsize to recommend them. They are so strong that three UNBRAKOS will do the job of five ordinary cap screws. Or, if you must use the same number of screws, you can safely use smaller UNBRAKOS. All UNBRAKOS have knurled heads for easier handling and faster assembly, and uniform sockets for maximum wrench engagement. Your favorite industrial distributor always stocks UNBRAKOS. STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

UNBRAKO® SOCKET SCREW DIVISION SPS JENKINTOWN, PENNSYLVANIA

lubricating "brains" built into any machine!

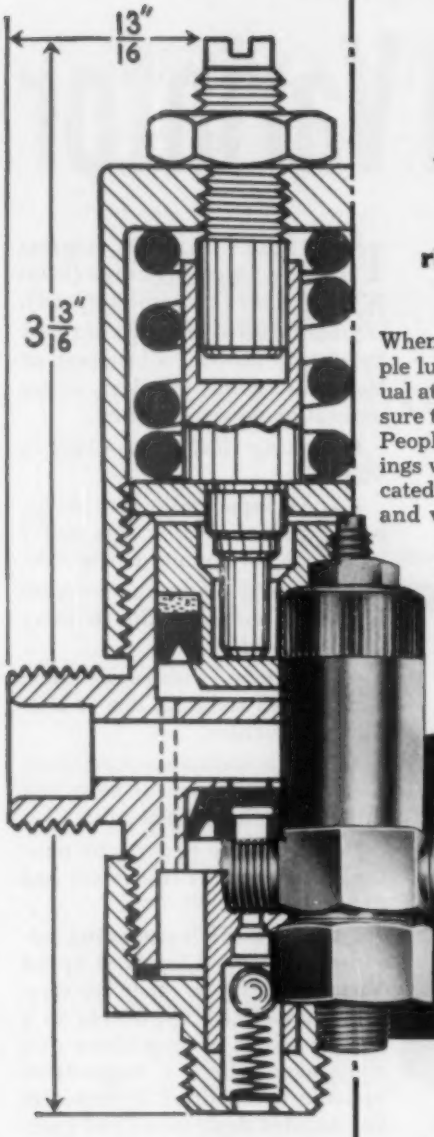
ALEMITE Accumeter®

lets you design automatic, fool-proof lubrication right into any machine—simply, economically . . . offers the operating savings industry will buy!

When a machine is designed with multiple lubrication fittings that require manual attention, the user of that machine is sure to encounter a number of problems. People being what they are, some bearings will be neglected, others over-lubricated. Further, hand lubrication is costly and valuable production time is lost when machines must be shut-down for lubrication.

You avoid all of these troubles with the Alemite Accumeter. This amazing valve fits directly on bearings—meters an exact shot of oil or grease *automatically—at pre-determined intervals—while the machine is in operation!* Time, production and maintenance costs are cut to the bone! With all these advantages, it is small wonder that 95% of all major plants buying machine tools specify centralized lubrication.

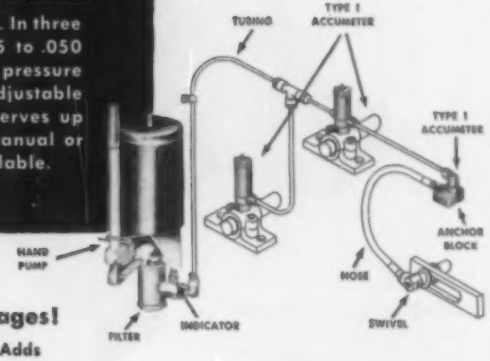
The Alemite Accumeter system is simple to design and build into any machine. Automatic Accumeter Systems assure you positive, low-cost lubrication. Find out about these automatic systems now. See the savings, the efficiency they add and you too will specify Accumeter!



Adjustable Output/Cap.

Type 1 Accumeter Valves

For fluid oil or light grease. In three sizes, delivering from .005 to .050 cu. in. of lubricant. Spring pressure provides gradual feed. Adjustable or fixed output. System serves up to 400 bearings. Either manual or automatic operation available.



Offers All These Advantages!

- Eliminates shut-down time for lubrication. Adds productive time to machine output.
- Seals completely against dirt, grit, water all the way from "Barrel-to-bearing."
- Prevents bearing troubles due to neglect or use of wrong lubricant.
- Services all bearings—including those inaccessible or dangerous—in one operation.
- Avoids work spoilage and bearing repairs due to over-lubrication.

Factory-tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—equal to 122 YEARS of *twice-a-day service!*

ALEMITE

A PRODUCT OF SW STEWART-WARNER

FREE!

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1850 Diversey Parkway, Chicago 14, Illinois

Please send me my free copy of the Alemite Accumeter Catalogue and Engineering Data Book.

Name_____

Company_____

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Can you use a compact drive with infinitely variable speeds?

HERE IT IS

Cleveland Speed Variator

NOW available in 9 sizes, ranging from one-half to 10 horsepower at 1750 input RPM.

INFINITELY variable, stepless speeds within a 9:1 range (from ⅓ to 3 times the input speed).

Smooth, instant change of speed by simple manual adjustment or by remote control devices, either manual or power operated.

Operating efficiencies—75% to 90%.

Coaxial input and output shafts, rotating in same direction, either clock-wise or counter clock-wise.

Ample bearing support for both input and output shafts to carry overhung pulleys.

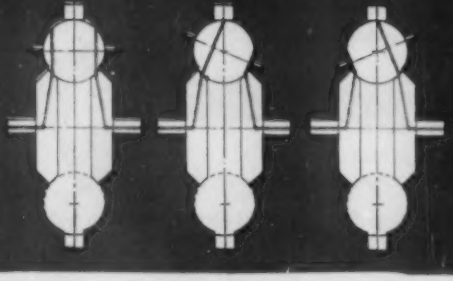
Compact and inherently quiet and smooth running, due to simple construction.

Minimum maintenance and long life, due to absence of belts and other complicated linkage.

Performance proved by prolonged tests in the laboratory and field operation.

These are the outstanding advantages of the Cleveland Speed Variator. It is now ready for service. Immediately applicable to a wide variety of machines and equipment where a dependable variable speed drive is required. For detailed description and specifications, write for Bulletin K-100.

HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axles on which the balls rotate (see diagrams, left, and cutaway view, right).

THE CLEVELAND WORM AND GEAR COMPANY

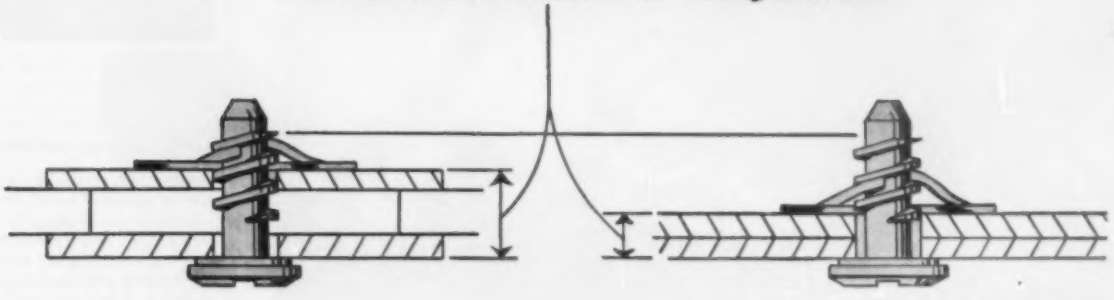
Speed Variator Division, 3279 East 80th St., Cleveland 4, Ohio

Sales Representatives in all major industrial markets

Why change cowl fastener size every time tolerances vary .010" ?

SOUTHCO quick release fasteners provide:

±TOLERANCES AS REQUIRED



Industrial tolerances, provided only by Southco Quick-Release Fasteners, are designed to accommodate variations in thickness normally encountered in metal working. No longer is it necessary to call out a different size precision type fastener because of a few thousandths variation. You eliminate a serious stock problem and reduce assembly time when you specify SOUTHCO.

You can easily choose the right Southco Quick-Release Fastener from a wide variety of stock sizes which include two diameters and three head styles.

The Southco Handbook makes it easy to pick the proper fastener. Write for your copy today. Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

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SOUTHCO

FASTENERS

PAWL • SCREW AND SPRING • DRIVE RIVETS • ANCHOR NUTS • ENGINEERED SPECIALTIES

OFFICES IN PRINCIPAL CITIES

SOUTHCO DIVISION
SOUTH CHESTER CORPORATION
236 Industrial Highway, Lester, Pa.

Please send me, without cost, the 24 page SOUTHCO FASTENER HANDBOOK ☐

Please have representative call ☐

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CITY _____ ZONE _____ STATE _____

WHEREVER TWO OR MORE PARTS ARE FASTENED TOGETHER; STANDARD AND SPECIAL DESIGNS FOR IMPROVED PERFORMANCE AND LOWER PRODUCTION COSTS

Another Gas Turbine Milestone

Photo at right shows Solar's first gas turbine driven aircraft generator set to be installed in a Douglas C-124C transport. The unit has just been removed from the plane after completing 500 hours of trouble-free operation. No servicing other than normal maintenance was required during this time, proving again the reliability of the Solar "Mars" gas turbine engine.

Solar pump on test at Navy Firefighting School

Portable fire pumps of the future will be powered by small gas turbine engines

THE IDEAL PORTABLE FIRE PUMP would be a unit of large output, light weight, small size, quick starting and easy maintenance. These ideal specifications are fully met for the first time by a new type of portable pump, powered by the Solar "Mars" gas turbine.

This portable fire pump of the future has been developed by Solar for the U.S. Navy Bureau of Ships. It delivers 500 gallons per minute at a pressure of 100 psi with a 16 ft suction lift. Dry weight, excluding fuel tanks and hoses, is only 175 lb. The unit is hand cranked and ready for full load in 15 seconds. It can pump its own weight of water in 2.5 seconds.

The Solar Mars gas turbine engine, prime mover of this unit, weighs less than 100 lb, is smaller than a 2-ft cube, and produces 50 hp using gasoline, diesel oil or kerosene as fuel.

Fire chiefs and other authorities both here and abroad have tested the Solar fire pump and given it their endorsement. It is not yet generally available because all current production of Solar gas turbines is going for military uses. However, production for commercial applications is expected in the near future. May we have your inquiry?

SOLAR AIRCRAFT COMPANY — SAN DIEGO, DES MOINES

DESIGNERS, DEVELOPERS AND MANUFACTURERS OF METAL ALLOY PRODUCTS

This is What Solar Offers You

Solar specializes in the manufacture of precision products from alloys and special metals for severe service. Solar's experience since 1927 is unduplicated in this field. Solar skills and facilities range from research, design and development through to mass production. Wherever heat, corrosion or difficult specifications are problems, Solar can help you solve them.

PLANTS. *In San Diego and Des Moines (photograph above). A total of 1,400,000 sq ft of floor space. Approximately 5,000 employees. Annual sales over $65,000,000.*

EQUIPMENT. *Production equipment for all types of metal fabrication —forming, machining, welding, brazing, casting, coating. Extensive laboratory and testing equipment. Facilities for development, prototype, limited or mass production.*

SERVICES. *Research, design, development, tooling and production engineering staffs. Experienced with all alloy steels, stainless alloys, super alloys, and titanium and its alloys. Government source inspection and Solar quality control meet rigid aircraft and commercial standards.*

CONTRACT PRODUCTION

Current orders include aircraft engine and airframe parts, alloy castings, pneumatic ducting, atomic energy components. Customers include some of the most honored names among aircraft and industrial companies in the U.S. and Europe.

SPECIAL PRODUCTS

Bellows. *"Sola-Flex"® bellows and expansion joints in many designs from ½ in. up to the world's largest, 28 ft in diameter.*

Gas Turbines. *Solar "Mars" 50 hp engines for auxiliary generator sets, ground carts, portable fire pumps; Solar "Jupiter" 500 hp engines in variable and constant speed models.*

Ceramic Coatings. *"Solaramic"® is the Solar trade mark for a family of coatings that protects metals from heat, corrosion, galling and abrasion.*

Controls. *Complete control systems utilizing the new Solar "Microjet"® principle for control of gas turbines, jet engines and pneumatic devices.*

FURTHER INFORMATION
Your inquiry regarding any Solar product or service will receive prompt attention. Address
Solar Aircraft Company
Department A-58
San Diego 12, California

Specify Bridgeport Phosphor Bronze◆

to make better spring parts...

for longer service life in switches,

relays and other electronic equipment

Bridgeport Phosphor Bronze (Alloys 35 and 36) has excellent resiliency, high flexural strength, good conductivity with superior corrosion resistance and ability to resist wear.

To use these advantages of Bridgeport Phosphor Bronze for your applications, contact your local Bridgeport Sales Office. Our technical service is always available to help you with your metals or methods problems.

◆ *One of the many Bridgeport Metals with High I.Q. (Inner Quality) for economical fabrication and improved products.*

BRIDGEPORT BRASS COMPANY ◆ BRIDGEPORT, CONNECTICUT

Serving Industry with a Nationwide Network of Conveniently Located Sales Offices and Warehouses
Mills in Bridgeport, Conn, Indianapolis, Ind., and Adrian, Mich.
In Canada: Noranda Copper and Brass Limited, Montreal

How the use of NATIONAL Seamless EXTRUDED Stainless Tubing *cuts nut manufacturing costs*

USING NATIONAL Seamless EXTRUDED USS Stainless (type 303) Tubing, the Tri-Clover Division of Ladish Corporation is now turning out hexagonal nuts in less time and at lower cost than they could using solid bar stock. The savings in material cost alone amounts to 11.77 cents per piece.

All machining on the nuts, except threading and O.D. finishing, is done in one operation on a 6-spindle, 3½ inch Conomatic automatic machine. A saving of five seconds in the time cycle was made by using the extruded hexagonal stock versus bar stock. The use of hex tubing has eliminated the cost and upkeep of boring tools —and, because tubing is considerably lighter than bar stock, it can be handled faster and with less difficulty.

NATIONAL EXTRUDED Tubing offers you high strength, uniformity, and dependability that only *seamless* tubing can give. For a better precision part, involving fewer operations and fewer machine hours, investigate NATIONAL Seamless EXTRUDED Tubing—made by the world's largest manufacturer of tubular steel products. Feel free to call our engineers if you'd like help in applying NATIONAL Seamless to your product.

* * *

National Tube employs a hot-extrusion process known as "Sejournet" in which white-hot billets of steel are squeezed into tubing of various shapes by a 2,500-ton hydraulic press and ram—a manufacturing method that insures absolute uniformity of wall strength.

NATIONAL TUBE DIVISION
UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

NATIONAL Seamless EXTRUDED TUBING

WALLS WITHOUT WELDS

UNITED STATES STEEL

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 12

Silicone Grease Saves Money; Increases Life of Alloy-to-Plastic Gears in Precision Gearmotor

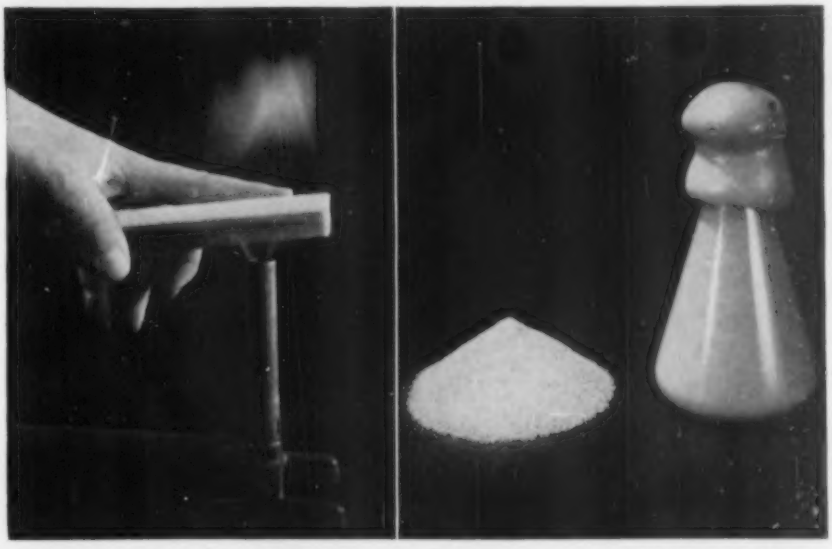
Using the best organic lubricants, maximum life of the gear set in a test model of a new precision gearmotor designed by Lee Engineering Company of Milwaukee, was only 100 hours. Temperature at point of contact between the nickel alloy worm and phenolic gears was so high that organic lubricants were rapidly separated and thrown out, even though the gearbox was fully packed.

Before major alterations in design were undertaken, Lee engineers tried Dow Corning 33 Grease, light consistency. A first trial run of 1200 hours showed no appreciable gear wear. Further tests proved that a basically sound design had been made practical by a stable lubricant.

With only enough Dow Corning 33 to fill the teeth required to give long service, Lee engineers found that even the initial cost of the silicone grease was less than that of a gear box-full of the organic grease previously tried.

Now in commercial production, these silicone lubricated precision gearmotors are put to many uses. For example, the ⅛ hp

(cont. pg. 2)



LOW DENSITY, NONFLAMMABLE SILICONE FOAMS HAVE HEAT DISTORTION TEMPERATURE ABOVE 700 F

There's a solution now to problems involving nonflammable, low density foamed structures with good thermal and electrical insulating properties, bouyancy after long exposure to water and superior compressive strength at temperatures in the range of 500 to 700 F.

What's more, such structures are easily made by foaming completely formulated silicone powders in place or sandwiched between metal sheets or silicone-glass laminates, by thermo-plastic shaping before curing or by cutting from cast sheets or blocks.

Identified as Dow Corning R-7001, R-7002 and R-7003, these non-toxic silicone powders produce foams with a uniform, multipore structure that is predominately spherical and unicellular. Densities in the range of 10 to 18 pounds per cubic foot can be produced. Water absorption after 24 hour immersion is in the range of 2 to 3 percent. Thermal conductivity is also very low.

Foamed structures made with these silicone powders are serviceable at temperatures far above the limits of organic foams. With a heat distortion temperature above 700 F, these silicone foams show slight structural change and little weight loss after 50 hours at 700 F. Samples heated to red heat by direct flame do not burn and show only slight surface change. Typical physical and dielectric properties of open pan foams made with these three silicone powders are shown in Table I.

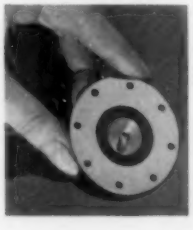
TABLE I

	R-7001	R-7002	R-7003
Expansion Temp, F	320	320	320
Density, lb/cu ft	12	14	16
Cell Size, inch diameter	<0.08	<0.08	<0.08
Compressive Strength, psi			
at 77 F	100	200	325
at 77 F, 200 hr at 500 F	100	190	210
at 500 F, 1/2 hr at 500 F	5	25	70
at 500 F, 200 hr at 500 F	20	45	80
Weight Loss, %			
during expansion	1.2	1.3	1.0
1000 hr at 500 F	3.5	2.6	2.6
1000 hr at 570 F	8.0	4.2	4.2
22 hr at 700 F	8.5	5.2	5.2
Water Absorption, %			
24 hr immersion	3.2	2.3	2.1
Heat Distortion Temp, F	>700	>700	>700
Flame Resistance	———	Do Not Burn	———
Dielectric Constant, 10^2 cycles	1.23	1.25	1.26
Power Factor, 10^2 cycles	0.0004	0.00102	0.00105
Thermal Conductivity			
BTU/hr/sq ft/°F/in. thickness	0.3	0.3	0.3

(cont. pg. 2)

5 Mil Silastic Membrane Diaphragm Sensitive from —22 to 230 F

Wanted—A diaphragm for aircraft use that can be produced in commercial quantities to register, in thousandths of an inch, changes in air pressure at temperatures from —22 to 230 F; must resist moisture; withstand severe vibration and shock.



That's a problem that Westinghouse materials engineers couldn't solve with such conventional materials as thin metals, natural or butyl rubber. So they met all requirements by developing commercial techniques for molding Silastic* membranes, as little as 5 mils in thickness, to aluminum discs. The process requires utmost cleanliness and precision including extremely accurate control of processing time, temperature and curing schedules. *No. 117*

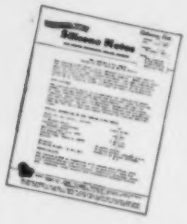
*T. M. REG. U. S. PAT. OFF.

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . .



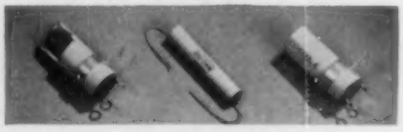
Hot off the press, new 8 page brochure on Dow Corning 41 Grease contains basic data on properties and applications. Features performance data in the form of case histories on savings in relubrication schedules, replacement and maintenance costs realized in a variety of high temperature, low speed applications including oven conveyor bearings, dolly wheels, injection valves and turbine governors. *No. 122*

New 1955 Reference Guide to Dow Corning silicone products gives in 8 pages a brief but comprehensive summary of the properties and applications for the silicone products that are most widely used. Products are indexed by type of application. With increasing effort devoted to product improvement and cost reduction, such a reference guide to this remarkably stable group of engineering materials becomes increasingly important to design, production and maintenance engineers. *No. 123*

Sylkyd 1400 Varnish is a modified silicone dipping and impregnating varnish with thermal stability intermediate between present Class B and Class H materials. It is designed for use at the hottest spot temperature of 155 C specified for Class F insulation as listed in the International Standards and recognized in Europe. Moderately fast curing, it has good bond strength and excellent resistance to oils and solvents. *No. 124*

Scratching or breaking of glass containers during filling operations or in shipping can be substantially reduced by treating them with Dow Corning EF-4010 Emulsion. Easily applied in the final steps of manufacturing glass containers, it requires no special equipment; curing temperatures are not critical. It can also be applied to aged glass and cured by heating. *No. 125*

Mold lubricants made with Dow Corning silicones and packaged in convenient, easy-to-use, aerosol bombs are commercially available from customers of ours. These aerosol propelled mold release agents keep molds free from cloudy film residues, rust and pin clogging. Applicable to hot or cold molds and economical to use, they are effective in the shell molding process, in metal stamping, in embossing leather, and in molding plastic and rubber products. *No. 126*



Silicone Resin Makes Wire-wound Resistors More Moistureproof

The Tru-Ohm Division of the Model Engineering and Manufacturing Co., of Chicago, has improved its line of wire-wound resistors by using a silicone-based cement that is much more resistant to moisture than the silicate-type cements previously used.

They make this cement by blending Dow Corning 996 silicone varnish with appropriate inorganic fillers. The material builds up well on the resistance wire and seals the element into the casing. It is set by air drying for 3 hours and then baking for 3 hours at 450 F.

Tru-Ohm produces the new resistors in 10, 15, 20 and 25 watt ratings for top-of-chassis mounting, and in 5, 7 and 10 watt ratings for axial leads. *No. 121*

SILICONE GREASE *(continued)*

unit shown here with a 40 to 1 gear ratio and a speed range of 10 to 200 rpm on the phenolic gear, is used to feed wire in an automatic welding machine. *No. 119*

Improve Space Heater Appearance With Modified Silicone Finish

Distinctive appearance and longer service life at no extra cost have been achieved by the Perfection Stove Company of Cleveland through the use of Glidden's Nubelon-HR, a modified silicone finish based on Dow Corning resins.

According to Perfection, "Rich as aged leather in appearance, the finish we get by applying a light coat of mahogany over a primary coating of russet colored Nubelon-HR is rugged, tough, and very heat resistant. It retains its color and luster for long periods of time. We have been using it for over two years on our oil heaters with excellent results."

Nubelon-HR is also more consistent and easier to apply than organic resin based enamels. Supplied at a proper consistency for spraying, the labor and material cost of thinning are eliminated, and its slightly higher cost per gallon is offset by the effectiveness of thinner coatings. Finished parts are baked 30 minutes in a traveling oven at a top temperature of 480 F. *No. 120*

SILICONE FOAMS *(Continued)*

Depending on expansion temperatures, the density of foams made with Dow Corning R-7001 range from 10 to 14 pounds; R-7002 from 12 to 16 and R-7003 from 14 to 18 pounds per cubic foot. All three of these silicone foaming powders can be used to make sandwich structures by adhering skins to preshaped forms.

Dow Corning R-7001 and R-7002 can be foamed in place. Because of its thermoplastic tendencies at temperatures in the range of 500 F, foams made with R-7001 can be formed into virtually any shape before final curing but they are not recommended for applications requiring high compressive strength at elevated temperatures.

Dow Corning R-7003 yields foams with the highest compressive strength at both room and elevated temperatures. In many applications foams made with these silicone powders can be cured in service.

Among many potential applications, foamed structures with these properties and handling characteristics may be useful as core materials for propellers and airfoils and, in the form of sandwich structures, as radomes and fire walls in aircraft. They hold promise as thermal insulation for range oven doors and portable ovens.

Low density combined with low water absorption and nonflammability suggest a possible use as buoyant components in boats and ships. Heat stability combined with good dielectric properties suggests application as electrical insulating materials at high temperatures or where conventional insulation is hard to apply. *No. 118*

Dow Corning Corporation, Dept. 8601, Midland, Michigan

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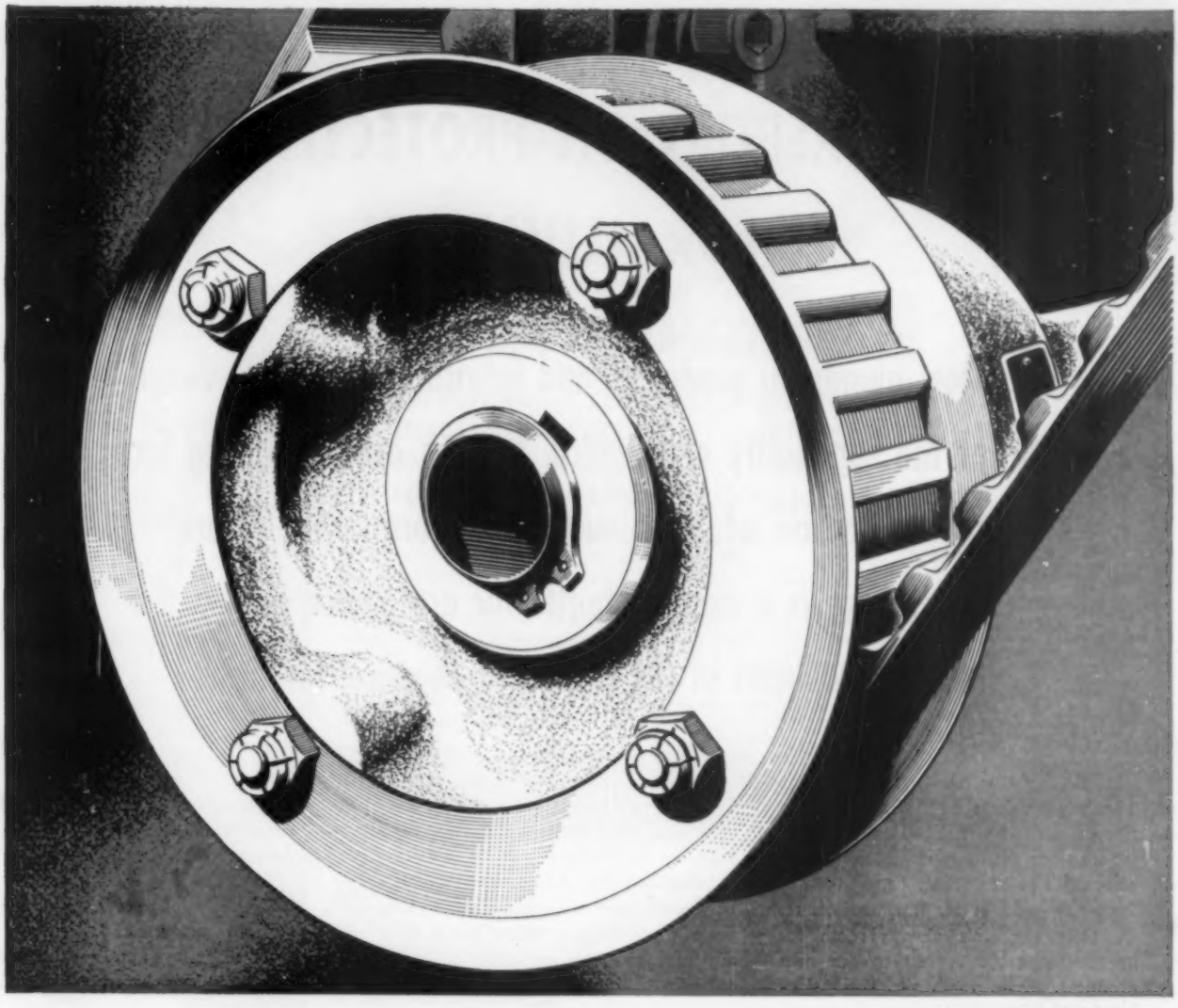
FLEXLOC AT WORK



MORE AND MORE FLEXLOC LOCKNUTS are being used to hold assemblies like this one together. This modern timing belt drive combines the flexibility of a steel cable belt with the positive action of a silent chain drive permitting its use at speeds up to 15,000 rpm.

FLEXLOC Self-Locking Nuts offer the same positive action as the drive. Once the locking threads are fully engaged, the nuts won't work loose, regardless of the vibration encountered. And FLEXLOCS are reusable.

FLEXLOCS are available in a wide range of sizes in any quantity. Stocks are carried by leading industrial distributors everywhere. Write for Bulletin 866 and samples for test purposes. STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

DO YOU KNOW? Standard FLEXLOCS clean rough threads on bolts, and make them even better. The locking threads on all-metal FLEXLOCS are not chewed up when used on rough bolts.

Standard FLEXLOCS lock securely on bolts varying in diameter tolerances. The all-metal, resilient locking sections of the nut accommodate themselves to the diameter tolerances.

Standard FLEXLOCS are one piece, all metal. They are not affected by temperatures to 550°F. Nuts lacking these features have a more restricted temperature range.

Standard FLEXLOCS lock securely—stopped or seated—when 1½ threads of a standard bolt are past the top of the nut.

Standard FLEXLOCS are not affected by moisture, oil, dirt or grit. They lock efficiently under all conditions, regardless of the vibration encountered.

FLEXLOC®
LOCKNUT DIVISION
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(*Advertisement*)

A SPECIAL REPORT ON PROTECTIVE FINISHES FOR ALUMINUM

Most aluminum producers and fabricators are well aware of the superiority of chemical finishes over anodizing for the protection of aluminum from corrosion. Naturally, then, there is a running battle for acceptance among the leading producers of the protective chemical finishes.

That's why, here at Allied, we have always studied your needs with regard to both our own and competitive processes. We're constantly trying to produce new and better finishes because we believe there's always room for improvement . . . even to our own products. Some years ago this policy led to the introduction of a process, long in development, that offered you a way to overcome anodizing's obvious technical complications . . . Iridite #14. This finish was far easier to use than anodizing, yet provided comparable, if not superior, quality. And, its cost was much less than anodizing.

But other finishes offering similar advantages over anodizing have entered the market. So . . . the current battle for acceptance. By any cost comparison Iridite #14 is the most economical. However, corrosion tests by users show contradictory results as to performance from Iridite #14 and other leading protective finishes for aluminum. Most tests show Iridite #14 superior, but some do not. The margin of difference, however, is always small. The truth is that all have proved good. However, our laboratory research indicated that still further improvements could be made.

That knowledge . . . plus our aim to give you even better protection and maintain the leadership of the industry, is exactly why Allied Development Engineers have been working for long years to develop a better finish than any of those now available, including our own Iridite #14.

Now the new finish is ready for you. It's called Iridite #14-2 (Al-Coat).

From a performance standpoint, Iridite #14-2 gives you two important advantages in the protective finishing of aluminum.

FIRST: in its fully colored brown film stage it provides corrosion resistance decidedly superior to previous processes.

SECOND: the basic brown film can be hot water bleached to produce a clear-type film with protection heretofore unobtainable from clear-type chemical finishes.

From an operating standpoint, new Iridite #14-2 gives you three important advantages.

FIRST: it provides consistently higher corrosion resistance for different aluminum alloys treated in the same bath.

SECOND: it provides a more uniform appearance for parts of different alloys and with varied surface finishes before treatment.

THIRD: its operating and technical characteristics are superior to those of other processes.

If you are using or planning to use a chemical finish for aluminum, you should have full details on new Iridite #14-2. Write us or send samples for free test processing. Or, for more immediate advice, call your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book. - - - ALLIED RESEARCH PRODUCTS, INC., 4004-06 EAST MONUMENT STREET, BALTIMORE 5, MARYLAND.

P. S. Even new Iridite #14-2 will be constantly measured against both your needs and competitive processes to make sure you get the best possible, most economical finish for your product that man and the laboratory can develop.

ANNOUNCING

A NEW LOW COST *Impact* AIR HAMMER

CUTS COSTS AMAZINGLY *in*

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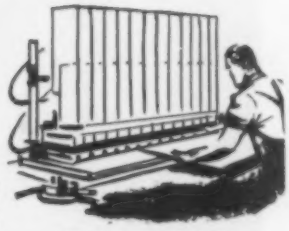

Most jobs done on expensive, heavy presses can *now* be done faster and cheaper by the light low-priced Mead Air Hammer using the new adjustable, spring*less* "Bullet Velocity" MEAD AIR TRIP! It delivers blows equivalent to 7½ tons down to as little as a few ounces—at several blows per second, if desired!

Enjoy the *competitive benefits* of really low cost production with this durable, powerful, improved Impact Air Hammer—another triumph by MEAD—pathfinder in air power automation. Put our "how-to-do-it" experience to work for you now. Ask the Mead Man today.

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Impact Hammer combines readily, inexpensively with Mead pneumatic timers, work-feeders to form money-saving semi-automatic machines. Reciprocating base available to feed small parts under hammer and eject them automatically. The **MEADMAN** can show you how to save—using these and *other* Mead air-operated devices!

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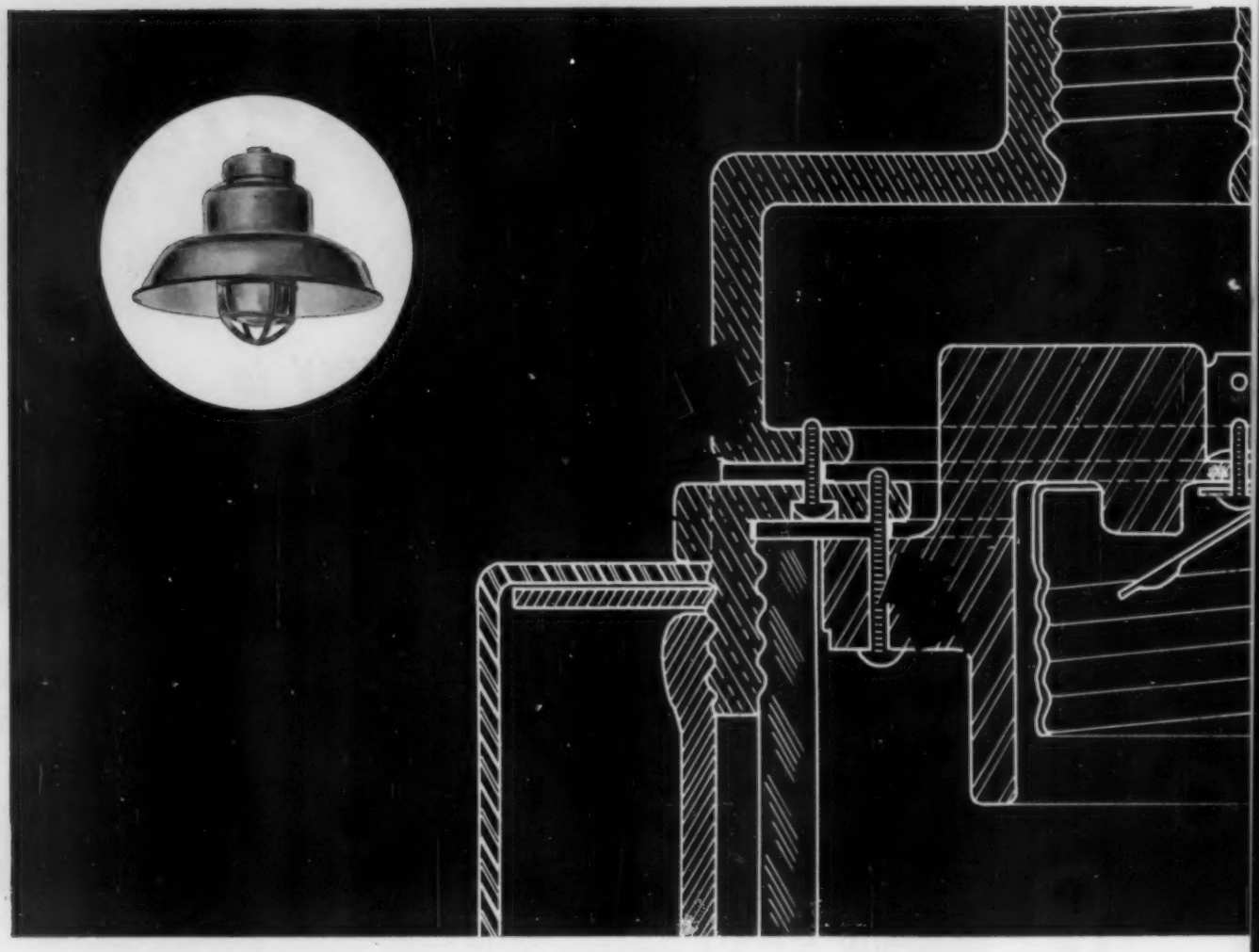
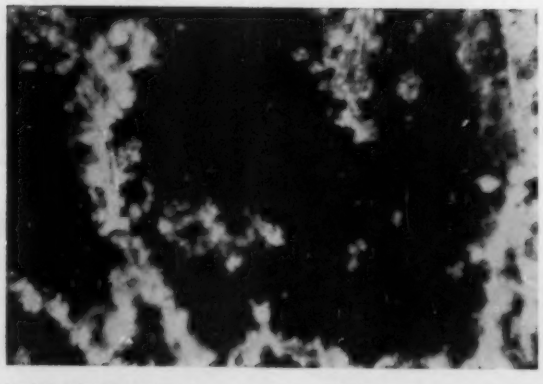
Pathfinder in AIR POWER AUTOMATION



improved fiber

seals vapor out of lamp,

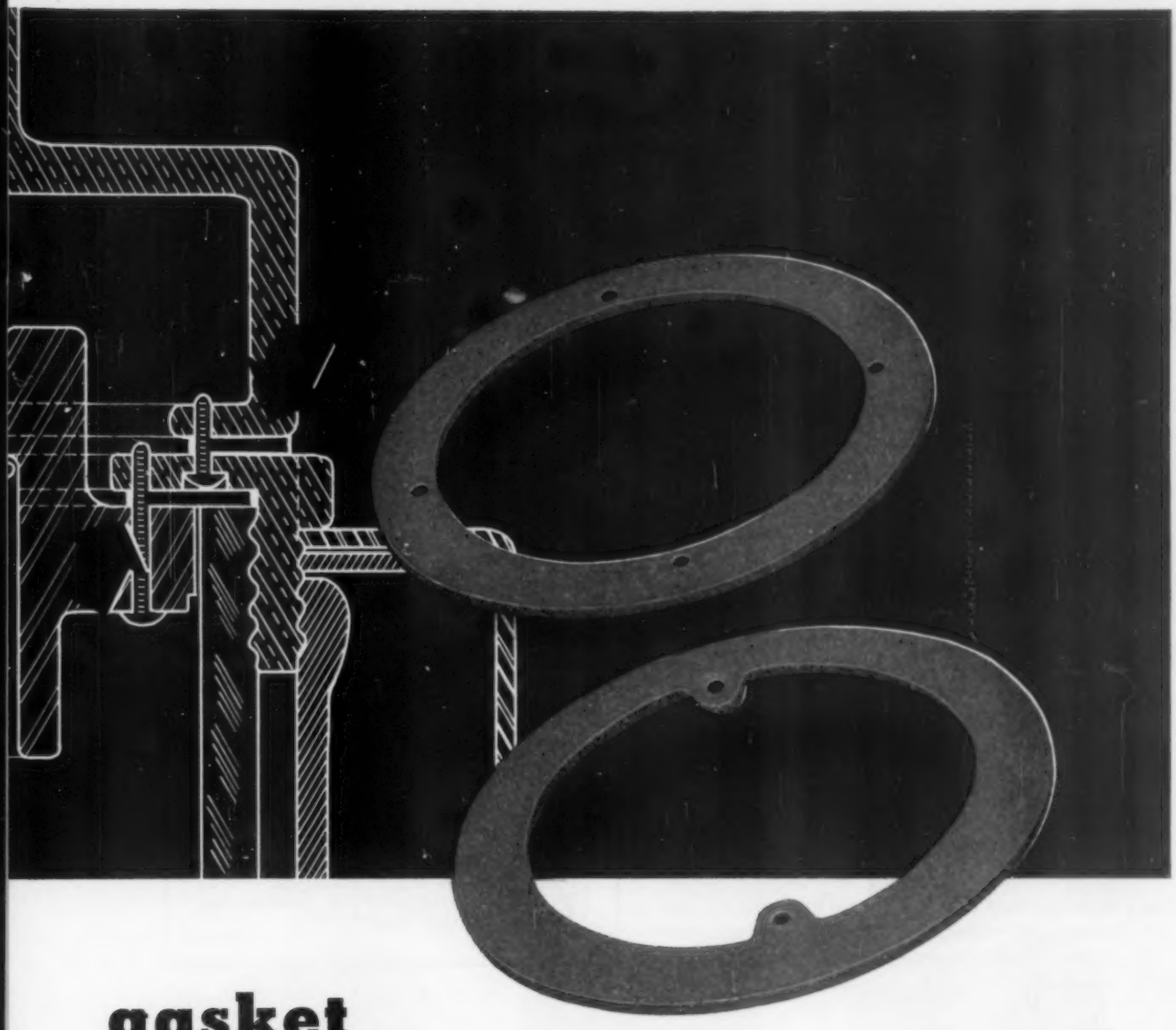


UNIFORMITY. This is a photomicrograph of Accopac in the watery pulp stage of manufacturing. Notice how each fiber has an even coating of latex. This completely uniform distribution of a non-extractable saturant is one of the keys to Accopac's many valuable sealing properties.

A dark residue forming inside the globes of vapor-tight light fixtures was seriously reducing the efficiency of the lamps.

When the manufacturer investigated, he found the cause in the two gaskets being used to seal between the cast aluminum housings and the porcelain receptacle. The 350° F. heat created inside the fixtures by 500-watt bulbs was vaporizing the binder in the gasket material. Though the gaskets still sealed, the vaporized binder condensed inside the globes and formed a residue that dimmed the lamps.

Extensive testing proved that the dimming problem could be solved by using an improved fiber gasket material—Armstrong CS-301 Accopac®. The new material retained its binder, even under the high temperatures generated by continuous, day-and-night operation of the lamp. And, though the flange was held by hand-tight-



gasket

solves serious dimming problem

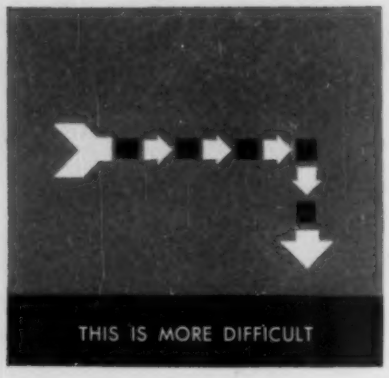
ened screws, Accopac was compressible enough to provide a lasting vapor seal.

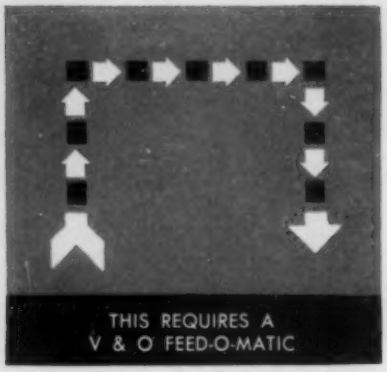
Accopac is well suited to varied sealing conditions because of its unique composition of cellulose fiber, cork, and non-extractable latex binder. The material is remarkably uniform, compressible, and dimensionally stable.

Though a recent development, Accopac already is widely accepted for sealing in consumer and industrial products. Where can you use it? Use Accopac wherever you need extra dependability in a low-cost gasket material.

FREE 24-PAGE GASKET MANUAL—Look in Sweet's product design file for "Armstrong's Gasket Materials"—or write for your personal copy. It contains facts on Accopac and other Armstrong Gasket Materials as well as useful information about gasket design. Write Armstrong Cork Co., Industrial Division, 7001 Irvin Street, Lancaster, Pa. **And be sure to specify Armstrong Gasket Materials when you order from a gasket fabricator.**

Armstrong Accopac





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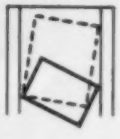
The small part can travel through three or more planes, through dangerous zones or past dangerous objects, and be placed with complete precision.

Feed-O-Matics eliminate production-slowing devices which are necessary for manual positioning of the parts. They trip devices which human beings never could be trusted to trip. Feed-O-Matic positioning is so highly precise that high cost intricate, fragile tools can be used where with manual feeding no one would dare to use them. Precision of production also is increased.

Feed-O-Matics can work with a minimum of operator attention. They can solve problems for hundreds of types of operations.

Write to us for full details. The V & O Feed-O-Matic® has an engineering story that will interest you.

WHY THE V & O LONG SLIDE PROVIDES BETTER ALIGNMENT



With the same running clearance, the longer the slide the less the possibility for angular misalignment. And we keep our running clearances very close indeed.

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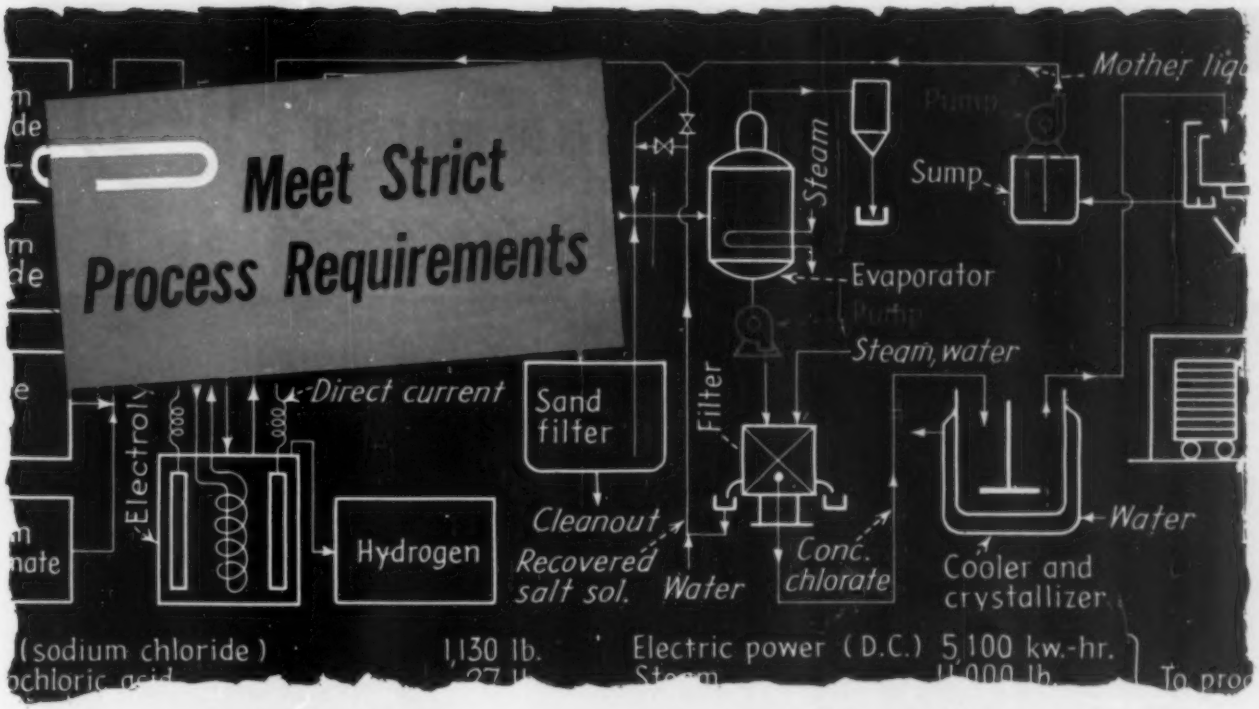
Battery of Feed-O-Matics in one user's plant.

T-shaped part being formed in secondary operation.

Feeding two pieces with each stroke of the press.



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Models 2F and 2J
to 2 g.p.m., 25-42 p.s.i.

Model D-11
to 7.5 g.p.m., to 18 p.s.i.

Model F
to 17 g.p.m., to 17 p.s.i.

Models U-17 and U-34
to 38 g.p.m., to 21 p.s.i.

Models W and Z
to 70 g.p.m., to 11 p.s.i.

Models 3F and 3J
to 5 g.p.m., 29-65 p.s.i.

Recent redesign of these close-coupled Centrifugal Pumps has gained tremendous ruggedness and allowed for a wide selection of power requirements. In every detail of size, weight, space requirements, power, and costs, Eastern pumps fill the bill for strict process standards.

Six standard models range from 1/8th to 3/4 H.P., with capacities up to 70 G.P.M., pressures to 65 P.S.I. Eastern Centrifugal Pumps are available in Cast Iron, Bronze, Stainless Steel, Monel, and Hastelloy "C".

Eastern's engineering service offers many special models to meet your specific needs as to capacity and construction. Recommendations entail no obligation, and your inquiries are invited.

NEW EASTERN CATALOG

Eastern Centrifugal Pump Catalog contains engineering data, performance charts, diagrams and helpful general information. Request Bulletin 110B.

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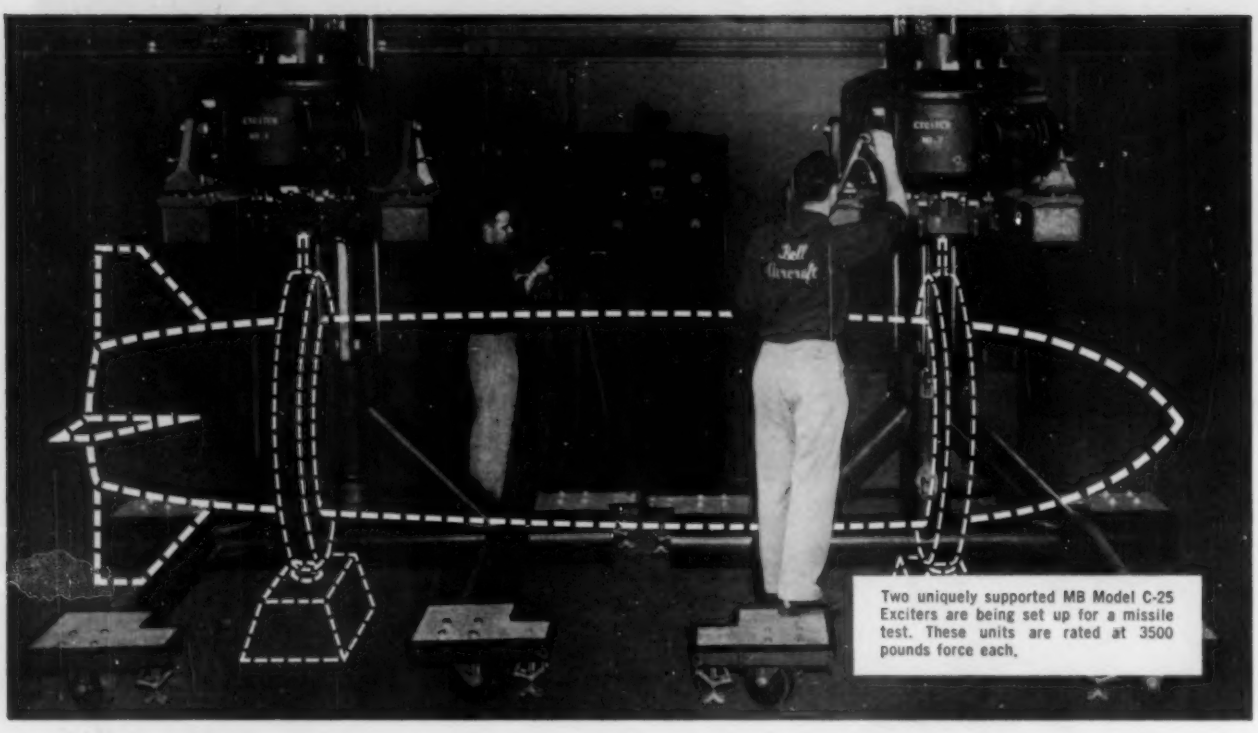
"Shake" tests add extra margin of reliability at BELL *Aircraft*



Two uniquely supported MB Model C-25 Exciters are being set up for a missile test. These units are rated at 3500 pounds force each.

Operation and quality quickly checked on

M B VIBRATION EXCITERS

Engineers of Bell Aircraft Corporation take advantage of the unusual help provided by shake testing – with a specially mounted setup of two MB Model C-25 Exciters for vibrating missiles.

BENEFITS OF SHAKE TESTING

Because small vibrations can be magnified in a complex missile structure, and because interactions of components are important, such testing checks vital systems. The MB shakers permit Bell engineers to produce conditions more severe than expected in service. In effect, a margin of safety can thereby be added to increase reliability of operation.

Moreover, vibration tests afford a quick, versatile means for checking quality of components. Defective and malfunctioning components are quickly detected.

To cap it all, substantial savings in manhours and fuel costs have been effected by substituting shake tests for hot firing of missiles prior to flight tests.

WHY MB VIBRATION EXCITERS?

Engineered by vibration specialists to deliver maximum performance, MB Shakers can be counted on for pure table motion and dependable operation to full rated capacity. MB's line of vibration testing "tools" is complete – from small specialized-duty shakers to the largest in existence today.

Prompt servicing provided by a special staff of MB engineers. For more information on shakers, send for Bulletin 1-VE-6

the MB manufacturing company, inc.

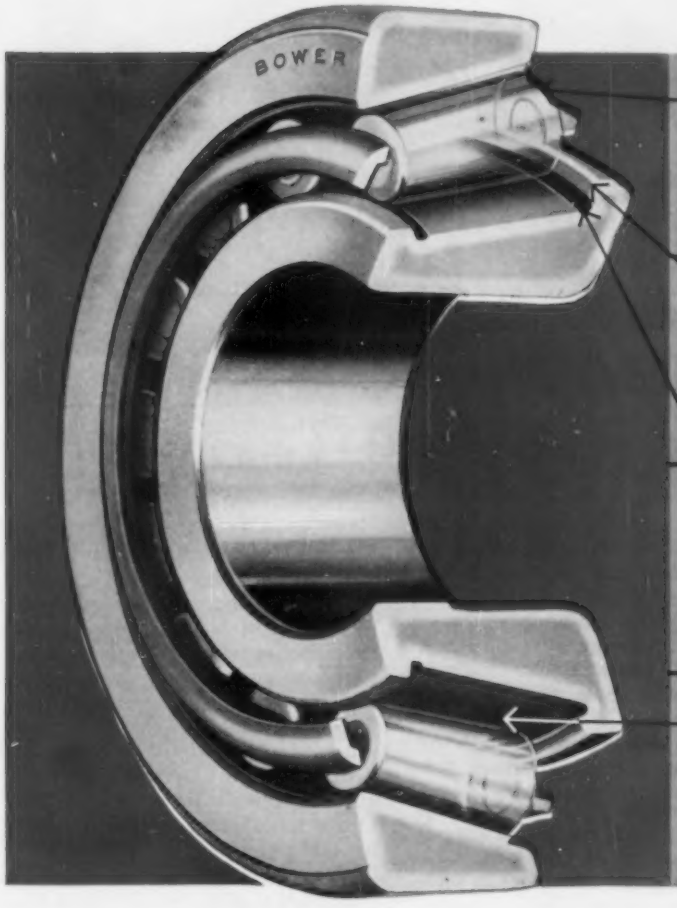
1060 State Street, New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO *ISOLATE* VIBRATION...TO *EXCITE* IT...TO *MEASURE* IT

Here's how BOWER Spher-o-honed design lengthens bearing life... cuts maintenance costs!

The Bower tapered roller bearing design features shown on this page are vitally important to every bearing user. For they illustrate the high quality, precision workmanship and close attention to engineering detail that go into *every* Bower bearing. Even more important, these Bower design features will give you significant bearing advantages such as reduced wear, longer bearing life and lower maintenance requirements. They've been thoroughly *proved* by extensive use in virtually every type of bearing application. If your product uses bearings—whatever it may be—specify Bower now. Or better yet, call in a Bower engineer while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



● **SPHERICAL ROLLER HEADS ARE GENERATED TO THE CONTOUR THEY ACQUIRE IN THE COURSE OF WEAR.** This helps Bower bearings hold adjustment and pre-load longer and better. Normal running-in time is virtually eliminated.

● **HIGHER FLANGE PROVIDES A LARGE, TWO-ZONE CONTACT FOR ROLLER HEADS,** thereby reducing unit pressure. This exclusive Bower feature improves roller alignment, greatly reduces wear and practically eliminates resultant "end play."

● **LARGER OIL GROOVE GIVES POSITIVE LUBRICATION** at the critical point—where the roller head thrusts itself against the cone flange. Here Bower design provides a larger recess that holds a generous supply of lubricant—increasing efficiency and decreasing wear.

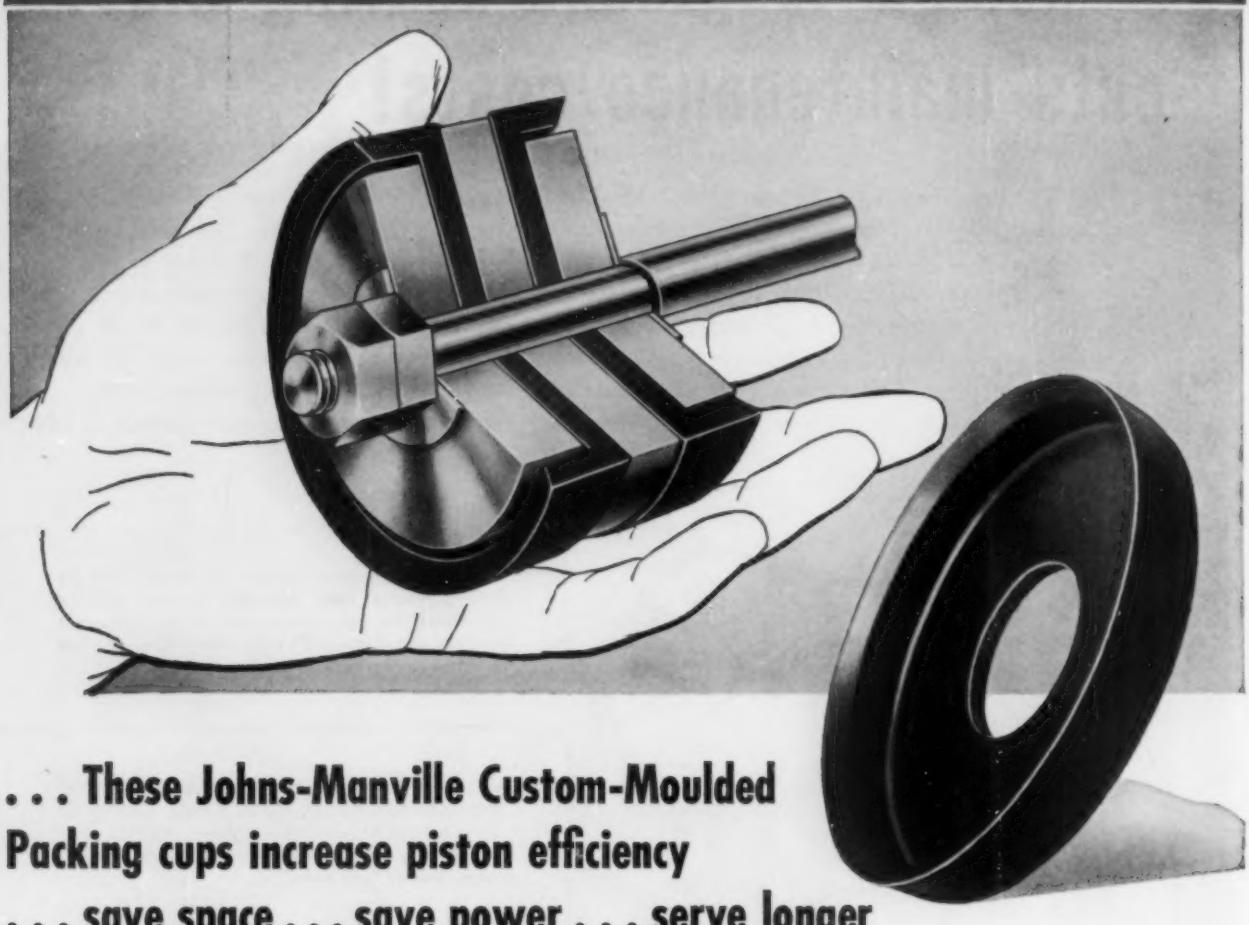
● **PRECISION RACES PROVIDE QUIETER, SMOOTHER OPERATION.** A Bower-developed grinding and honing process provides a micro-smooth surface of hard, crystalline base metal. In this way, close-tolerance precision is built-in to stay! No final adjustment is needed!

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS FOR EVERY FIELD OF TRANSPORTATION AND INDUSTRY

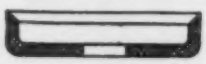
BOWER
ROLLER BEARINGS

SPHER-O-HONED

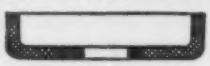
Looking for a more efficient piston design?



. . . These Johns-Manville Custom-Moulded Packing cups increase piston efficiency . . . save space . . . save power . . . serve longer



TYPE A . . . The Type "A" J-M Moulded Packing Cup is the "standard" for use on the pistons of pumps and on various hydraulic and pneumatic mechanisms. The lip forms a tight seal under discharge pressure, but relaxes on the reverse stroke, reducing friction and conserving power.



TYPE B . . . This type of cup is essentially the same as Type A, except that the leading edge of the lip is square instead of beveled. This construction provides greater strength where the lip may be exposed to distortion or excessive wear due to openings in cylinder walls.

Johns-Manville Moulded Packing Cups can help you improve piston designs. They provide a highly efficient seal . . . improve equipment performance . . . lower operating and maintenance costs. These custom-made packings are extensively used on all types of slow moving pistons and rams operating under high or low pressures and temperatures.

Johns-Manville Moulded Packing Cups may be used on practically all air or hydraulic-operated cylinders. For instance, those which are in such equipment as reciprocating pumps, hydraulic jacks and presses, pneumatic chucks, governors, lift trucks, grease guns, valves, drilling and boring machinery . . . or on any other equipment where efficient piston design is essential.

You have your choice of a number of styles and compositions of these precision-moulded cups to meet temperatures and pressures encountered in hydraulically operated equipment. Types "A" and "B," shown here, are most widely used on inside-packed pistons with the outside edge or lip contacting the cylinder wall or liner. Other types are available, however, for other services.

If you would like more information on these or other types of Johns-Manville Custom-Made Piston Packings, get in touch with your Johns-Manville Packings Distributor, or write Johns-Manville, Box 60, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

The answer to most of your questions about stainless steels are right at your finger tips, when you use Crucible's unique new Stainless Steel Selector.

Want to know the machinability characteristics of a stainless grade? Resistance to corrosion or scaling? Physical or mechanical properties? You can get the answers to these and other questions simply by setting the arrow on the Selector slide at the proper window. It's just as quick and easy as that.

And almost as fast as you get the answer, you can get the steel you need. For many of the REZISTAL stainless steels shown on the Selector are carried in stock in Crucible warehouses conveniently located throughout the country.

To get your free copy just fill in and mail the coupon. Better do it now.

HOW THE SELECTOR WORKS:

Start with the problem. For example, resistance to corrosion in contact with copper sulfate. Just set the slide at the proper index number shown on the Selector (in this case on the back), and you have the answer in a second – grades 302 and 316 are fully resistant to this form of attack.

Crucible Steel Company of America
Dept. PE Henry W. Oliver Building
Pittsburgh, Pa.

Name_____

Company_____ Title_____

Address_____ City_____ State_____

CRUCIBLE first name in special purpose steels

54 years of Fine steelmaking

STAINLESS STEELS

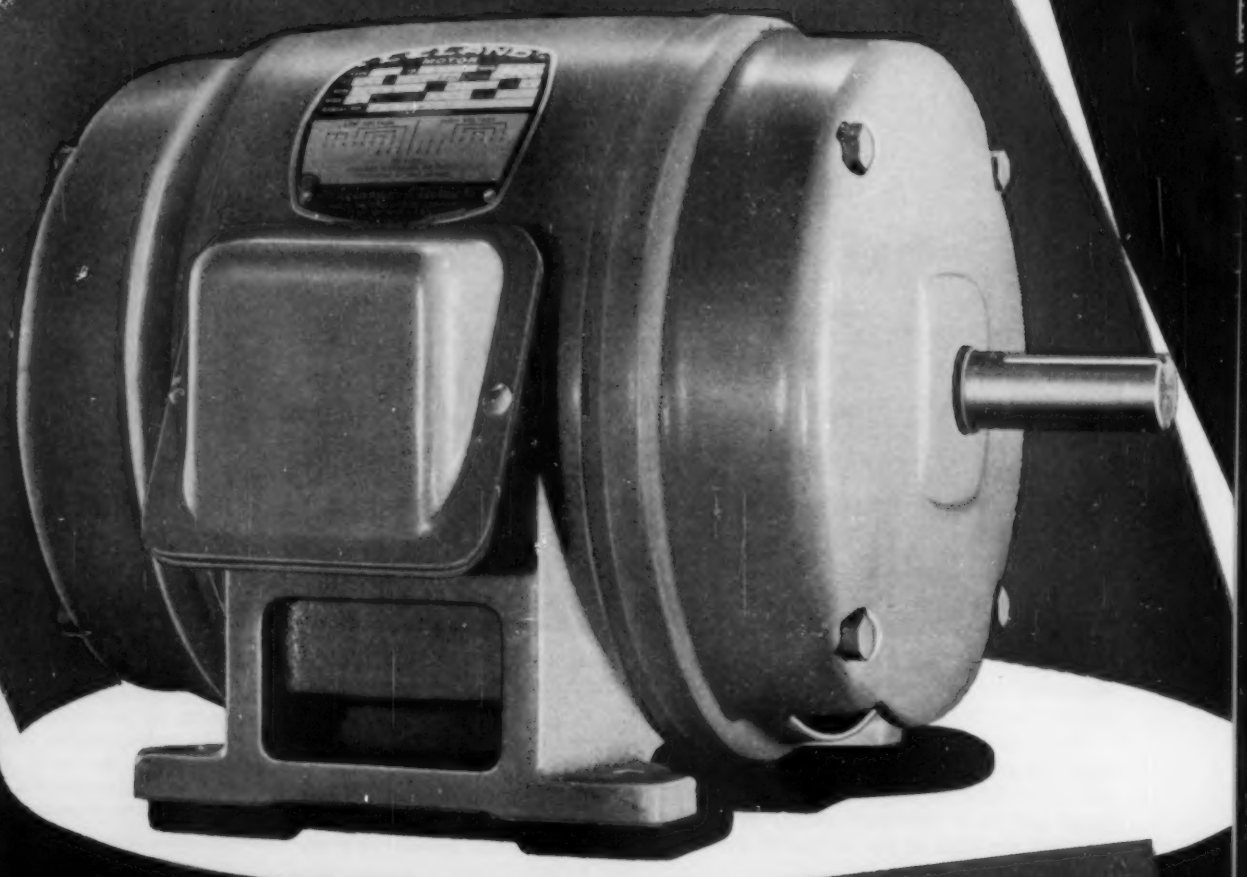
CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

new

. . . and more efficient, too!

- Custom-designed for regular production!
- Built for a lifetime of service!

LELAND LOADSTAR MOTORS



Here are LELAND'S outstanding qualifications for producing the finest of motors to the new NEMA standards:

★ Extensive and continuing experience in developing and producing, for our Armed Forces, hundreds of thousands of *portable* generator units and *airborne* inverter units and controls. Leland designs consistently meet and frequently surpass specifications so satisfactorily that they virtually become the criteria for other suppliers.

★ More than 33 years' "creative electrical engineering" experience in supplying manufacturers with high-quality custom-built special motors, or standard LELAND motors adapted to the particular requirements of their products.

★ The combined, industry-wide engineering and development resources of American Machine & Foundry Company.

★ A unique combination of modern, mass-production facilities and custom craftsmanship, resulting in extra care in critical operations and greater versatility in production.

Hitch your product to a "Loadstar"!

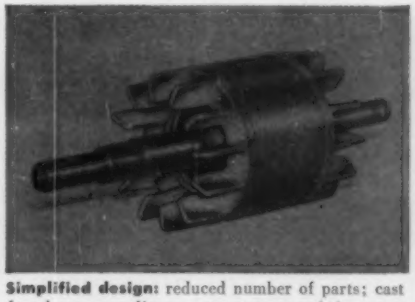
YOUR NEWEST PRODUCT will have added value, added efficiency, when powered by the equally modern, equally efficient LELAND *"Loadstar"!* It's the most advanced LELAND motor ever designed for regular production!

LELAND engineers have taken full advantage of the rare opportunity presented by the reframing program to incorporate into new LELAND designs many *added* improvements not actually a part of simple reframing. In this way every user of a new *"Loadstar"* motor benefits directly from LELAND's exceptionally pertinent experience in the continuing development and manufacture of special and lightweight power units and inverters for Aviation and the Armed Forces... one of the roles in which LELAND's creative electrical engineering has particularly distinguished itself.

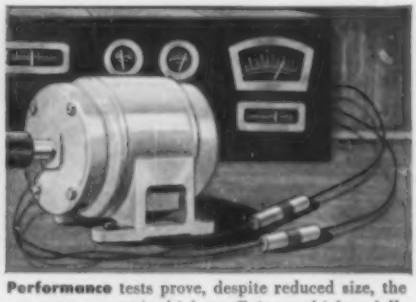
No wonder, then, that the *"Loadstar"* outshines them all!

Some features of this new line of smaller, lighter integral horsepower motors are shown below. Others were covered in a previous advertisement. For the complete story, and frame dimension details, write for Bulletin No. 103.

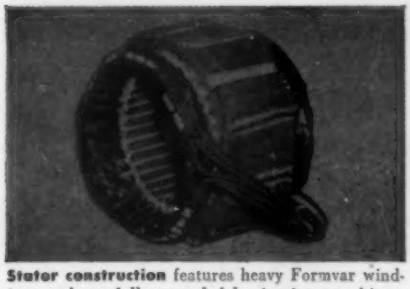
Generous-sized, double-shielded, sealed ball bearings, *lubricated for life*, prevent entrance of abrasive grit. Precision-machined bearing bores give uniform rotor-to-stator air gap.



Simplified design: reduced number of parts; cast fans have same diameter as rotor, permitting rotor removal from either end; standardized components fit open or enclosed frames.



Performance tests prove, despite reduced size, the new motors attain higher efficiency, higher full-load speeds, approximately 30% higher starting torque and breakdown torque.



Stator construction features heavy Formvar windings and carefully annealed lamination punchings.

Non-rusting, easily read aluminum name plate plainly shows all wiring connections.

Large conduit box turns to four positions. Smudge-proof numbered markers identify leads.

New "Loadstar" polyphase, dripproof motors in 1, 1½ and 2 HP (180 frames) now ready. Totally enclosed and explosion-proof frames—also higher horsepower and single phase motors—available soon.

Another AMF Product

LELAND MOTORS

LELAND motors in previous NEMA standard frames will continue to be available for replacement and the convenience of present customers.

THE LELAND ELECTRIC COMPANY, DAYTON 1, OHIO, *Division of American Machine & Foundry Company*

Bright good looks that **WON'T** *wear off ... value that* **CAN'T** *wear out!*

STAINLESS steel brightwork (ask about it on the car *you* buy!) has much more than surface attractiveness. It has built-in, timeless beauty. Beauty that goes all the way through—doesn't scratch off or rust off. Beauty that lasts—outlives the car itself. And beauty that's practical . . . requires no weary polishing, just ordinary washing. Wherever it's used, Allegheny Metal delivers something extra in good looks, strength, service life and resistance to rust and wear. This time-tested stainless steel has given thousands of products a competitive edge . . . maybe there's a place in *your* business where it can boost sales appeal or reduce costs. Let's help you look. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

WAD 4933 B

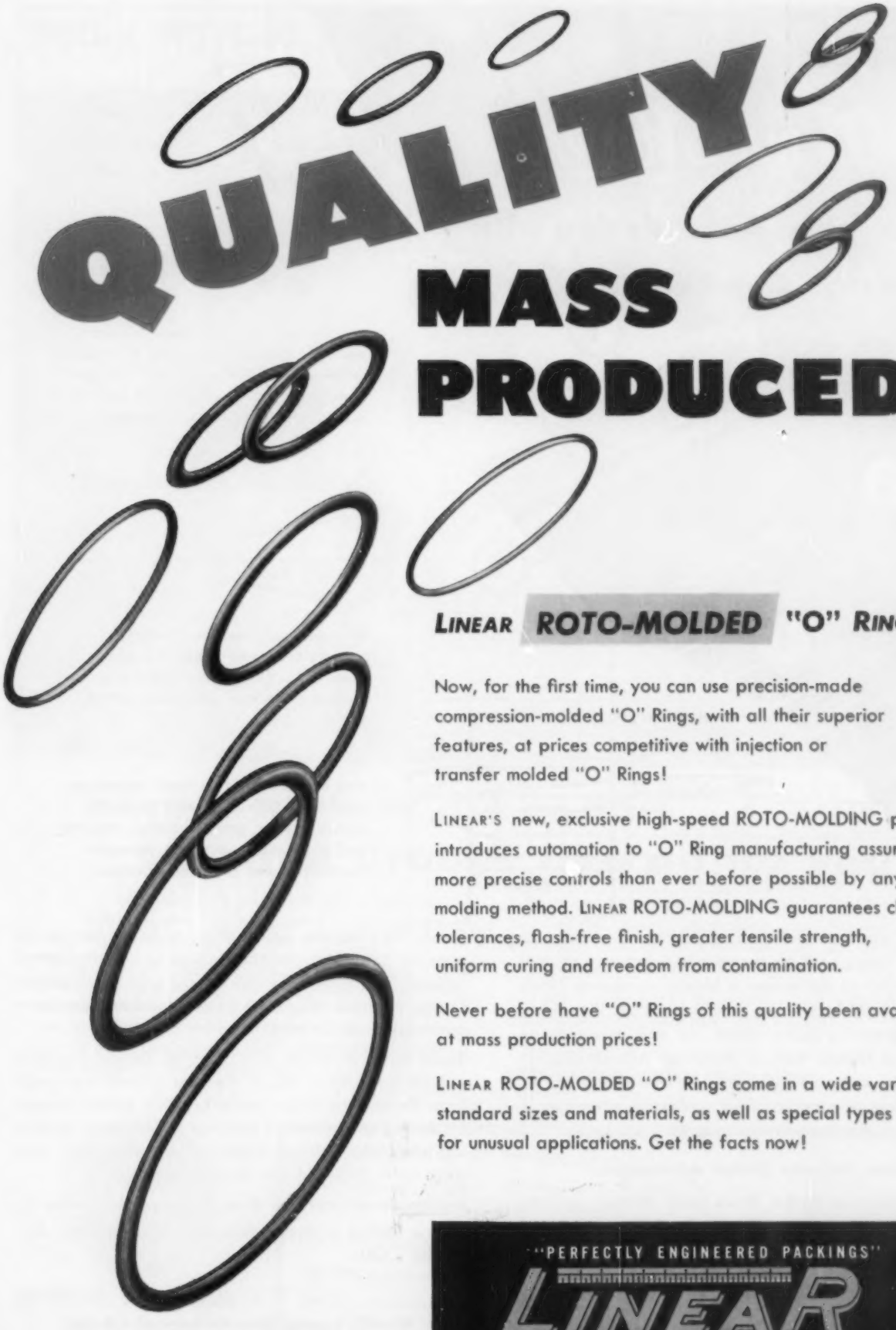
You can make it **BETTER** with

Allegheny Metal

Warehouse stocks carried by all Ryerson Steel plants

AL® TIME-TESTED STAINLESS STEEL

QUALITY MASS PRODUCED!



LINEAR ROTO-MOLDED "O" RINGS

Now, for the first time, you can use precision-made compression-molded "O" Rings, with all their superior features, at prices competitive with injection or transfer molded "O" Rings!

LINEAR'S new, exclusive high-speed ROTO-MOLDING process introduces automation to "O" Ring manufacturing assuring more precise controls than ever before possible by any molding method. LINEAR ROTO-MOLDING guarantees closer tolerances, flash-free finish, greater tensile strength, uniform curing and freedom from contamination.

Never before have "O" Rings of this quality been available at mass production prices!

LINEAR ROTO-MOLDED "O" Rings come in a wide variety of standard sizes and materials, as well as special types for unusual applications. Get the facts now!

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

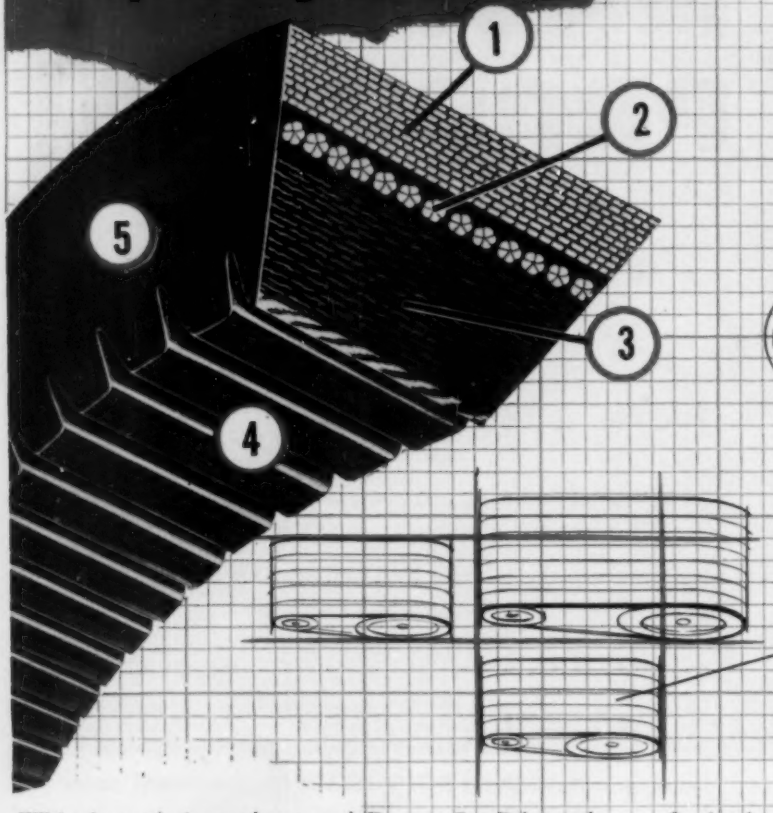
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

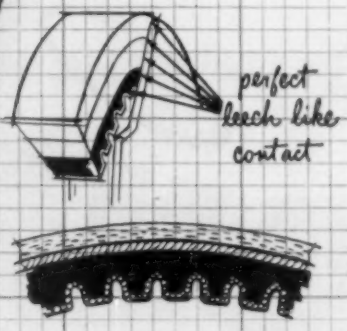
You get

40% more Power

for your drive design with

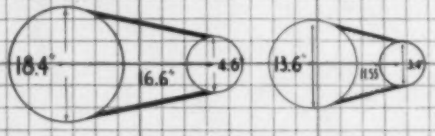
Dayton Cog-Belts*





SMOOTH, DIE-CUT SIDES GRIP SHEAVE GROOVES TIGHTER, GIVE MAX COEFFICIENT OF FRICTION. PREFORMED, BUILT-IN COG ELIMINATES BELT BUMPING OR INCHING AROUND THE SMALLEST SHEAVES.

Cog-Belts save space and weight



"B" CROSS SECTION 4 TO 1 SPEED RATIO COG-BELT DESIGN EFFECTS A 30.6% SAVING IN CENTER DISTANCE — A 26% SAVING IN WEIGHT — A 47.2% SAVING IN DRIVE AREA.

40% BONUS POWER PERMITS DESIGN FOR NARROWER SHEAVES, FEWER GROOVES SAVES WEIGHT, SPACE AND COST, PERMITS USE OF SHEAVES WITH 25% SMALLER DIAMETERS AND SHORTER CENTERS.

With the exclusive and patented Dayton Cog-Belt, made only by Dayton, available horsepower is increased by 40% per belt. One of the reasons is because its smooth die-cut sides, precisely angled for ideal contact in the sheave, provide greater gripping power and give maximum coefficient of friction without distortion. And in addition, you can also save on weight, space and cost without sacrificing one iota of construction or application advantages to gain this higher horsepower rating for your design.

Check These Exclusive Design Advantages:

1—The Tension Section flexes easily without cracking, straining or loss of life. **2**—The Load Carrying Section has maximum stretch-proof strength. **3**—The Compression Section has cross-wise rigidity. Patented Stiflex composition prevents squashing, buckling, binding. **4**—Preformed, integral Cogs flex uniformly for full grip . . . another Dayton patented exclusive. **5**—Smooth, die-cut sides assure positive grip, *full* power.

These exclusive design advantages of Dayton Cog-Belts provide flexibility in solving the most difficult drive problems. Because the longer-lasting Cog-Belt permits designs for shorter center distances, narrower sheaves, fewer grooves and fewer belts, you save weight by as much as 28%, save space up to 25% and save original belt cost.

For specific help on your drive design problem, write to: Dayton Rubber Company, Industrial Division, Dept. 87, Dayton 1, Ohio.

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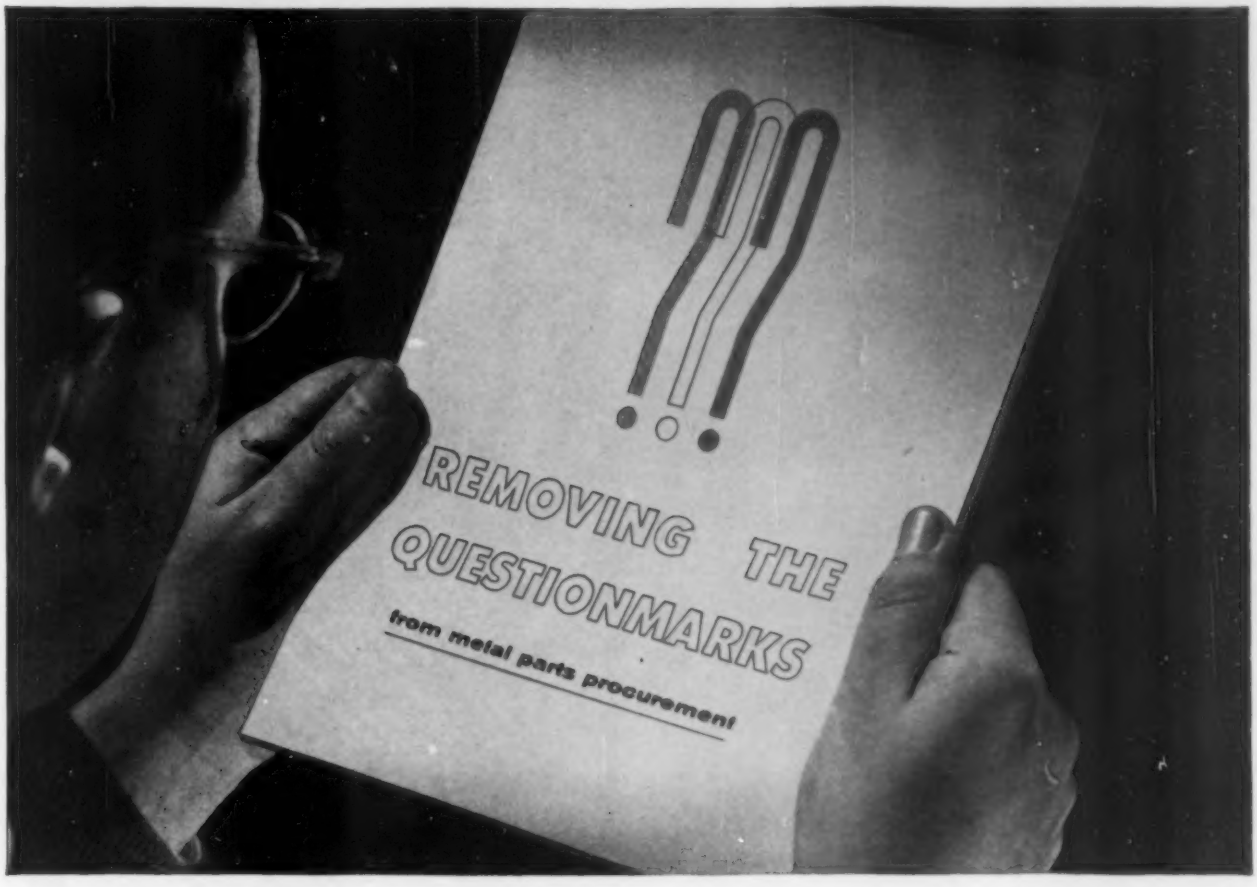
Dayton Rubber
Since 1905

World's Largest Manufacturer of V-Belts
Dayton Rubber Co., Industrial Division
Dayton 1, Ohio

specific ways to increase profits thru metal stampings



here's a clear cut report on what Crosby can do for you

Are you faced with rising costs and stiffer competition? How certain are you that your metal parts embody all possible improvements and economies?

"Removing the Questionmarks" will tell you how The Crosby Company is staffed and equipped to help you solve numerous problems in the procurement of metal parts. It shows how this progressive Company can assist both large and small plants in the design and production of cost-saving, product-improving, metal stampings.

It defines the many ways in which Crosby shows its initiative by making suggestions and recommendations when quoting. It explains how estimates are carefully prepared and how delivery dates are made to be kept.

It will enable you to measure the true value of Crosby services in meeting your parts requirements.

Make sure that this informative report reaches your desk without delay by using the coupon below.

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REMOVE ALL DOUBT— GET A CROSBY ENGINEERED QUOTE

THE CROSBY CO. 205 Pratt Street, Buffalo 4, N. Y.

Mail a copy of your report "Removing the Questionmarks from Metal Parts Procurement" without cost or obligation.

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There is no Substitute for SEALMASTER *Quality!*

Today's product designer is well aware of the importance of quality in the components used in each piece of machinery he engineers.

SEALMASTER Ball Bearing Units assure maximum performance and their exclusive combination of features provide a decided competitive advantage for any machinery manufacturer. Four features you will find in no other bearing unit except SEALMASTER are shown at left and explained briefly below. These are features to insure greater performance for the products you build. They are features you will want to learn more about. Write for full information:

(1) Zone Hardened Inner Race Ring for positive race to shaft holding power.

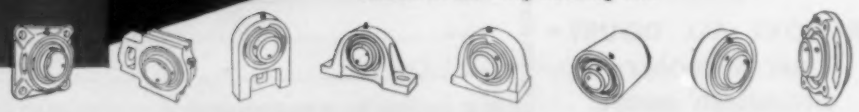
(2) Ball Retainer eliminates ball wear, traps grease and prevents churning.

(3) Locking Pin & Perimeter Dimple prevents rotation of outer bearing race and assures positive lubrication.

(4) Seal keeps dust and dirt out and lubricant sealed in for long bearing life.

WRITE TODAY FOR BULLETIN #454

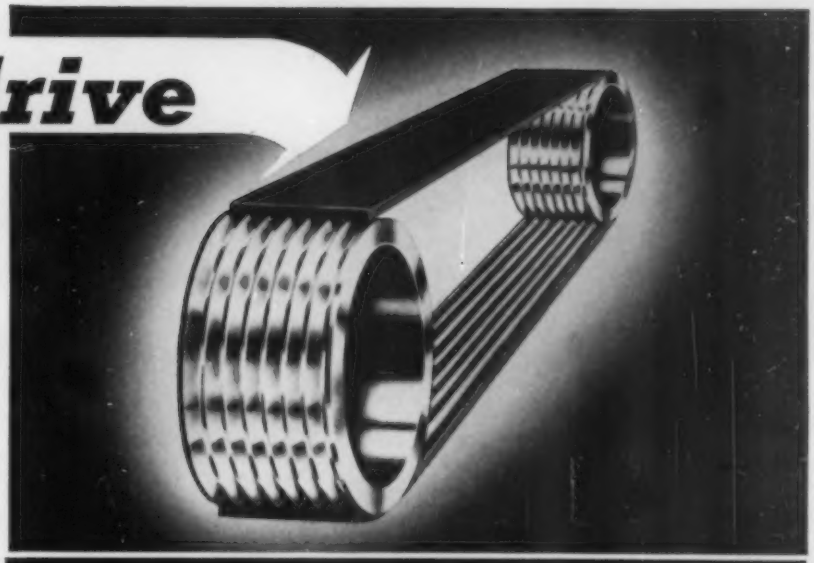
SEALMASTER BALL BEARING UNITS



SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 9 RIDGEWAY AVENUE, AURORA, ILLINOIS

THIS NEW DRIVE SOLVES MANY OLD PROBLEMS

. . . R/M poly-v® drive



Here is Raybestos-Manhattan's answer to equipment designers' needs for an "ideal" belt drive . . . the Poly-V Drive . . . R/M's patented and completely new concept of power transmission. Poly-V Drive combines high V-groove grip with the strength and simplicity of flat belts in a single, endless rubber belt. A series of parallel V ribs molded lengthwise around the inside circumference mate precisely with the specially designed sheaves. No other belt drive offers comparable advantages for the improved design of new and existing power equipment.

SINGLE UNIT BELT

Uninterrupted strength member extends across full width of sheave. All parts of belt work together to give uniform pull. No more matching problems, or belt turn-over.

NARROWER SHEAVES . . . OR MORE POWER IN SAME SPACE

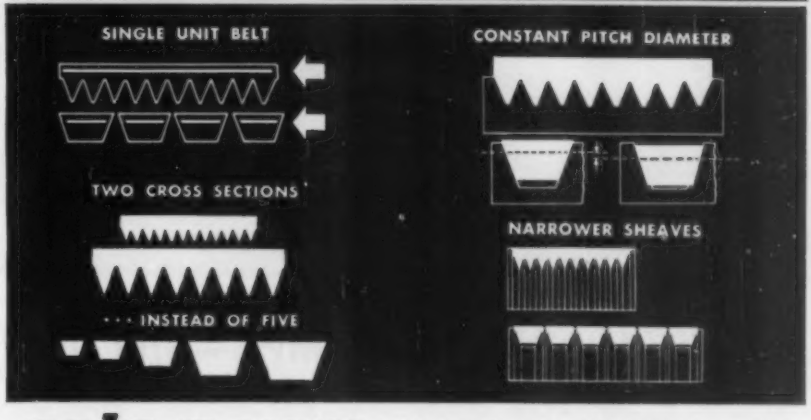
Width of Poly-V Drive is only ⅔ to ¾ of the width of standard multiple V-belt drives because Poly-V Belt has higher horsepower capacity per inch of width.

CONSTANT PITCH DIAMETER

Poly-V Drive eliminates sinking of belt in sheave grooves and maintains constant pitch diameter and speed ratio at *all* loads and runs smoother, cooler. There is less wear on belt and sheaves.

TWO CROSS SECTIONS INSTEAD OF FIVE

Instead of 5 V-belt cross sections, only two cross sections of Poly-V Belt, in appropriate widths, are required to cover every heavy-duty power transmission problem. This allows greater interchangeability and lower inventory of belts and sheaves.



poly-v DRIVES IMPROVE HEAVY DUTY POWER TRANSMISSION IN EVERY INDUSTRY

Ideal for manufacturers of equipment for agriculture, oil drilling, metal working, mining, wood working, paper, textiles, and other original equipment design applications. The outstanding advantages of Poly-V Drive have proved it to be the greatest advancement in power transmission drive design since the multiple V-belt! R/M engineers are prepared to give you every assistance in solving your power transmission design problems with Poly-V Drive, and will gladly furnish complete engineering data. Ask your R/M representative for additional information, or write for special bulletin #6638.

® Poly-V is a registered Raybestos-Manhattan trade mark. RM-536

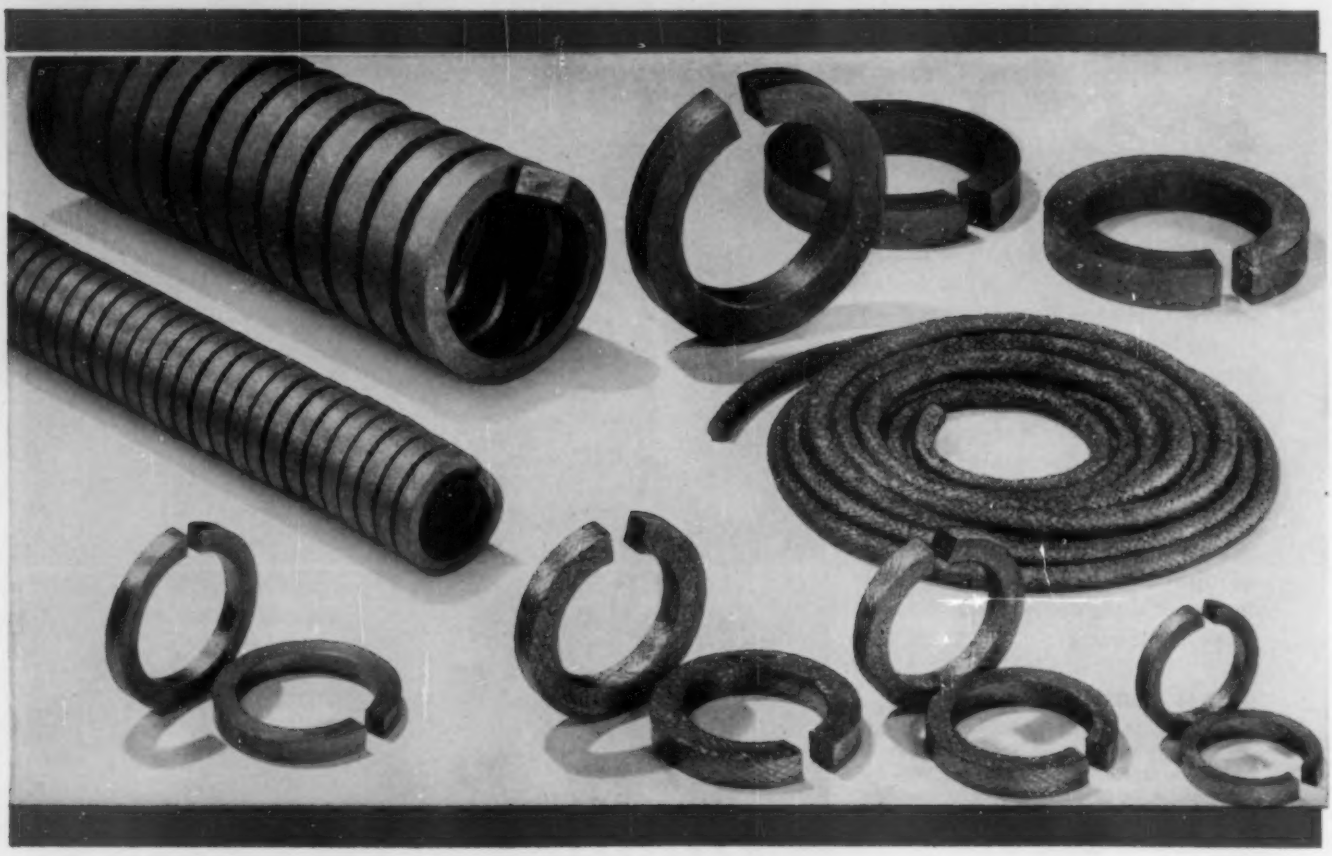
R/M

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings Asbestos Textiles • Packings • Engineered Plastic, and Sintered Metal Products • Bowling Balls

CALL ON R/M ENGINEERING SERVICE



OUTSTANDING FOR PUMPS—R/M UNIVERSAL PACKINGS

The packings pictured above—R/M Universal Plastic Packings—are precisely engineered to the requirements of pumps and valve stems. Their performance under many different service conditions is uniformly outstanding. They can always be counted on to provide low friction and the resistance desired to materials handled, pressure and heat. The superlative ability of these packings to retain their lubrication is but one of the many secrets of their success—the lubricants are locked in so securely that even after wear sets in, the effectiveness of the bearing surface remains unchanged. R/M Universal Packings are particularly popular with maintenance men because they permit the practice of preventive rather than corrective maintenance.

The complete R/M line includes packings and gasket sheets for use against air, gas, water, steam, oil, chemicals, solvents, food products and hydraulic fluids. R/M also makes a wide variety of "TEFLON"* products and an unusual number of asbestos textiles. If you have problems involving any of these materials or products, feel free to call on R/M's specialized engineering service.

**DuPont's trade-mark for its tetrafluoroethylene resin*

For booklet shown, or other data, write, phone or wire:

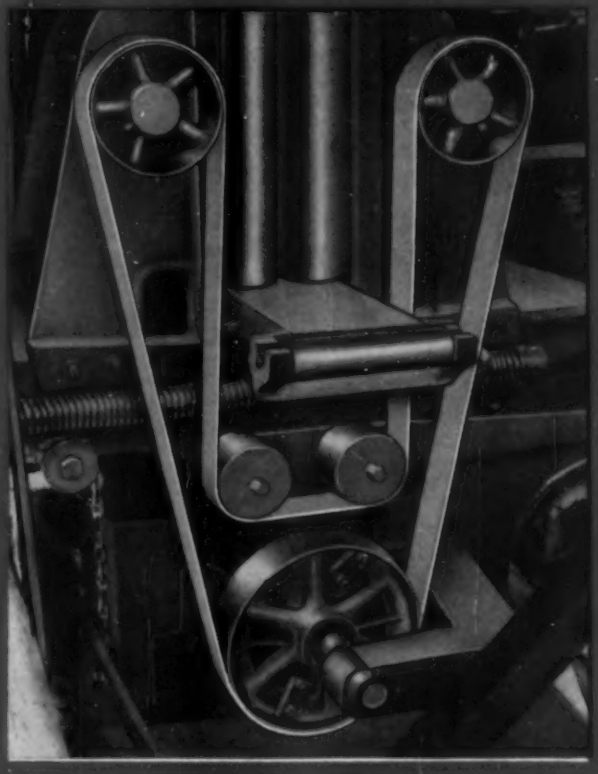
PACKING DIVISION OR ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings | Fan Belts and Radiator Hose | Mechanical Packings and Gaskets | Abrasive and Diamond Wheels | Industrial Drive Belts | Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS



R/M ENDLESS BELTS

Condor Whipcord Endless is an all-purpose belt for all types of drives, regardless of length, speed or pulley size. A highly flexible belt, it is ideal for machines where serpentine drives supply power for several operations—for built-in drives, small pulleys, reverse bends, short centers and high speeds. It is unaffected by moisture or atmospheric changes, and with exclusive splice design has been known to outlast 2 to 10 ordinary type endless belts on some drives. Whether your design calls for transmission belts, conveyor or V-belts, hose or molded rubber products—let R/M specialists work with you.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
Gregory 3-2000

FRICTION MATERIALS

Unlike other manufacturers, R/M works with *all* kinds of friction materials, from asbestos to sintered metals. This means that when you consult an R/M engineer you can be sure of completely unbiased advice on which materials are best for your application.

Raybestos-Manhattan has been the world's largest maker of friction materials for over 50 years. Whatever your brake or clutch requirements, count on R/M experience, and R/M manufacturing and testing facilities, for a friction material exactly suited to your needs.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
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RAYBESTOS-MANHATTAN, INC.

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Conveyor Belts

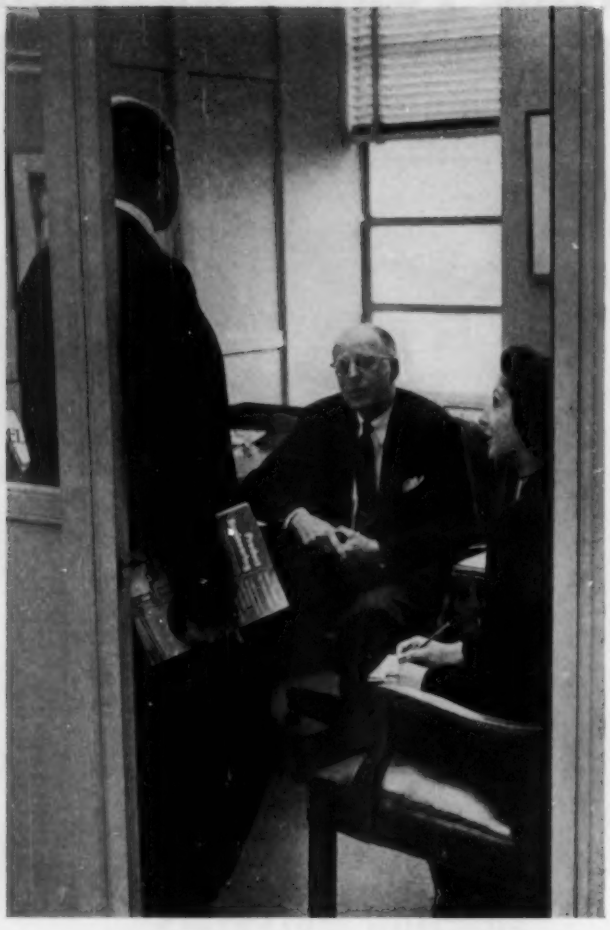
Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics



"What's fired you up like this about the Original Equipment Market?"

Few, if any, generations have faced such revolutionary new markets as you face today. Research developments are moving forward so fast that the new products which can now be designed and manufactured are spectacular in their implications. They promise to obsolete completely today's machinery, equipment, and appliances, and to create tremendous new markets as they do so.

You can quickly visualize the surging future of design engineering by reading *Product Engineering's* January report on "Science and Engineering . . . Today and Tomorrow." Documented by personal visits with 221 scientists in over 50 of America's top research centers, this special report will tell you just what *is* happening in the development of new materials, processes, and other wonders for design engineering to now put to work.

We publish this remarkable report as *Product Engineering* begins its second quarter-century of service to design engineering. And you will surely agree with us that this is more than ever a time for looking ahead . . . for recognizing that a second "industrial revolution" is in the making . . . for planning now how *you* will fare in the growing markets new-product designs are pioneering.

And in all your market planning, the advertising pages of *Product Engineering* will have a leading place. Above the pages of any other magazine published, they take the story of your parts, materials, components, and finishes to the men whose new-product designs are creating tomorrow's great-growth markets. Sell *Product Engineering's* 28,000 paid subscribers, and you sell *the heart* of design engineering leadership and progress. This has been true for twenty-five years. It will be even truer in the years ahead.

"Read Product Engineering's January issue, and you'll feel the same way. Its story on design engineering's future is the most provocative reading I've done in years."

THE MEN
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NEW PRODUCTS
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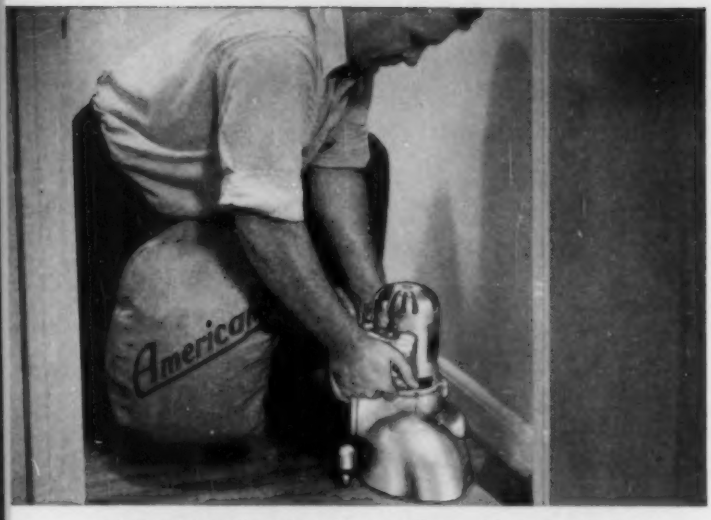
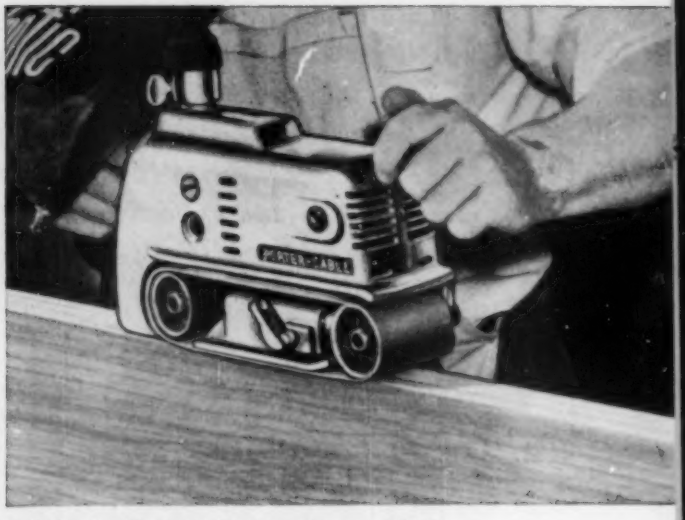
General Electric Engineers Help

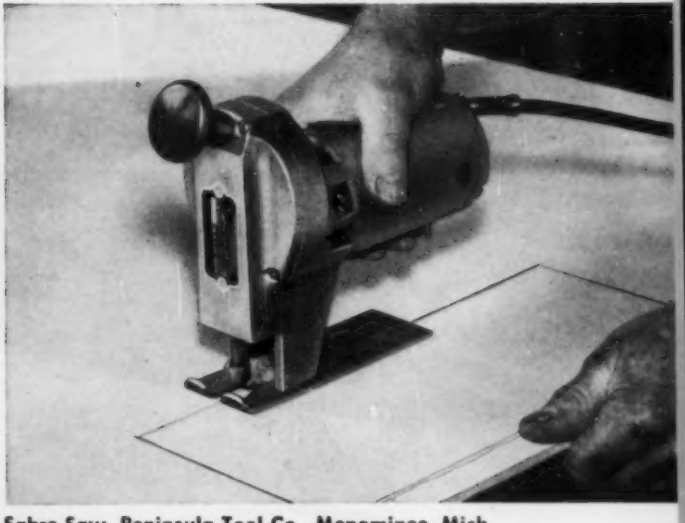


Spinner Edger, American Floor Surfacing Mach. Co., Toledo



Belt Sander, Porter-Cable Co., Syracuse, N. Y.

Impact Tool, Miller Falls Co., Greenfield, Mass.



Sabre Saw, Peninsula Tool Co., Menominee, Mich.

Garden Tiller, Rototiller, Inc., Troy, N. Y.

Smoothie Sander, Clarke Sanding Mach. Co., Muskegon, Mich.

Top Power-tool Manufacturers Solve Motor Application Problems

An Example of G-E Engineering Service Available to You

The eight popular "do-it-yourself" tools pictured here are all powered by General Electric fractional-hp motors. During their design, G-E engineers worked closely with customer engineers to assure proper motor application. As a result of this combined G-E product and engineering service, both tool manufacturers and tool users can count on top performance.

FOR SOME TOOLS, a slight modification of an existing G-E motor design filled the power needs. For others it was necessary to design special motor parts. In one case G-E engineers contributed a suggestion which led to complete tool re-design in order to assure top motor performance. In every case G-E fhp motor engineers—making use of G.E.'s unequalled development facilities—provided complete motor application service.

WHATEVER YOUR PRODUCTS—from aircraft components to plant process equipment to home workshop tools—you can get this same help on fhp motor application. And chances are that G-E experience will cover your specific area of need. For in designing, manufacturing, and applying over ***100,000,000*** fhp motors, G-E engineers have worked with customers on thousands of different products.

ACT TODAY to put your motor problems in the hands of the motor industry's leading application engineers. Just contact your nearest G-E Apparatus Sales Office. General Electric Co., Schenectady 5, New York. 704-38

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½" Sioux Drill, Albertson & Co., Inc., Sioux City, Iowa

Impact Tool, Ingersoll-Rand Co., Athens, Pa.

LORD FACTS ON VIBRATION

ANYONE CAN MAKE VIBRATION CONTROLS

Practically every mechanism is subjected to either destructive wear or impaired performance because of vibration or shock . . . and practically anyone could make a unit to "solve" these problems to some degree. It is important, however, that the vibration control units contribute to improved operation and efficiency of the mechanism—and at reasonable cost.

The use of makeshift or incorrectly applied units usually makes the condition worse instead of better.

LORD has devoted over 30 years to the successful solution of thousands of vibration and shock problems. LORD research, engineering, and production facilities have produced over 27,000 types of highly effective control units for all kinds of applications.

Exceptional engineering and manufacturing skills plus the use of only the best materials provide users of LORD products with several outstanding advantages:

EFFECTIVE VIBRATION ISOLATION—LORD units reduce operating vibration, shock, and noise to the lowest practical level—over a long, service-free operating life.

LOWER MAINTENANCE COSTS—Effective isolation provided by LORD systems reduces destructive vibration—lowering maintenance adjustment and parts replacement costs.

FLEXIBILITY IN USE—LORD extensive design and production facilities have developed a group of standard mountings of several types. These are adaptable to many standard vibration control applications and provide effective and economical solutions to a wide range of problems.

The extensive facilities at LORD are available on request for solution of your problems, whether they are simple or complex. Simply call or write the Home Office, Erie, Pa. or the LORD Field Engineer nearest you.

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LORD BONDED RUBBER

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Perspectives

DESIGN AND DEVELOPMENT

THE CONTROL OF MILITARY RESEARCH

The pros and cons of "Who Should Control Military Research" have been argued privately for years, but recently the problem was thoroughly aired by the Military Operations subcommittee of the House Committee on Government Operations, headed by Rep. R. Walter Riehlman of New York. A number of the country's distinguished scientists gave testimony, and 50 others were asked to write in their views. About 1,500 pages of testimony were collected, ranging from the value of research-development projects to military strategists, to such minor organizational problems as the use of the Officers Club by civilian scientists in military research organizations located in out-of-the-way places. The result was a strong indictment of defense research management.

THE SCIENTIST'S VIEWPOINT

As the scientist sees it, rule by command in military laboratories is inconsistent with the manner in which effective basic research is accomplished. In some military organizations, the technical program is under a technical director. In others, the technical director serves only as an advisor to the military commander. But in every instance, the final decision rests with the military commander, who in most cases is there because it is one of the stops on his tour of duty. In two or three years, he is rotated to a new post, and another officer, unfamiliar with the projects going on, is put in charge. Direction of the program is more difficult because of the limited technical training of most military commanders. The scientist keeps abreast of the latest scientific thinking, which depends on the free exchange of information—something difficult to achieve in a military operation.

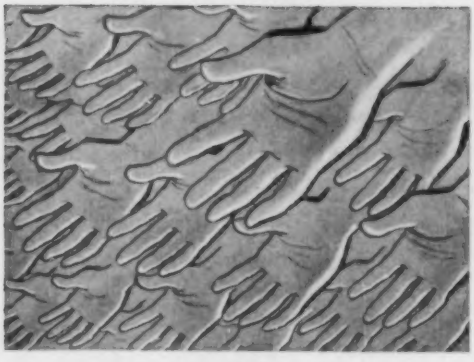
FOR CIVILIAN CONTROL

The entire problem is not a simple one, and these were just a few of the points studied. But those who favor the side for civilian control feel that there is a clear division between the research which should be directed by the military, and that which should be controlled by civilians. These two classes are: (1) research and development on weapon improvement and perfection; and (2) strategic research and development directed towards new weapons, systems, and their applications.

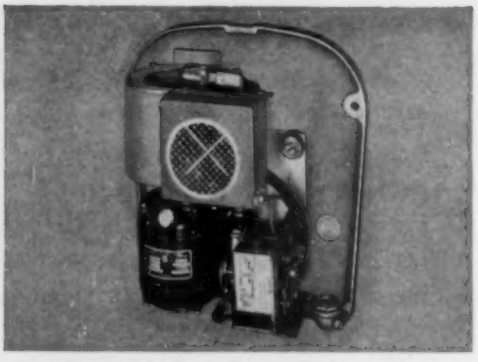
Type (1) is ideally suited to the military; it could not operate successfully any other way. But type (2) is completely different. As one witness put it: "It is research and development toward new strategic alternatives. This type of research has never been done successfully under the direct control of the Armed Forces, and no single example to the contrary can be cited. All of the new weapon concepts that now produce important correction to our strategic deficiency can be traced to the Office of Scientific Research and Development (OSRD)." *(Continued on page 125)*

Why Bodine motors were selected for Electric Aire hand dryers

1 This is an Electric Aire hand dryer . . . the kind you see in theatre or railroad station washrooms.



2 It's one of the least expensive ways known for drying hands . . . 2,000 hands for 16c.



3 The dryer's blower is powered by a Bodine Type NSE-12, 1/10 H.P., 6500 rpm, universal, resiliently mounted motor.

BODINE MANUFACTURES FRACTIONAL HORSEPOWER ELECTRIC MOTORS FOR:

dictating machines
electric typewriters
revolving signs
adding machines
coin counters
therapeutical equipment
film projectors
printing timers
automatic dispensers
electronic controls
stapling machines
tape dispensers
automatic wrappers
compressors
check signers
recorders
type setting machines
display units

. . . and for many other applications.

4 Electric Aire says motor's life expectancy in dryer is 25,000 hours . . . enough to dry all the hands in Detroit and Los Angeles.

5 This is Mr. E. S. Hewitt, president of Electric Aire Engineering Co., producers of the Electric Aire hand dryer.

"For 20 of my 35 years in the electric hand dryer business I have used Bodine Motors because they require less service and fewer replacement parts. It appears that their exceptional dependability lies in the high quality materials employed, unusually good workmanship, and thorough inspection. This is substantiated by the fact that windings seldom fail and sleeve bearings stand up better under neglect and hard use. Our experience with your ball bearing motors is still limited."

6 This is what Mr. Hewitt has to say about Bodine Fractional horsepower electric motors.

7 Be sure *your motor* is as good as *your* product. For detailed information, contact Bodine Electric Co., 2260 W. Ohio St., Chicago, Ill.

Ask for a sample copy of "The Motorgram," a bi-monthly publication discussing application and design of fractional horsepower electric motors.

OPERATION OF THE OSRD

The OSRD was set up in 1941 with Dr. Vannevar Bush as its director, and is the best example of civilian-military cooperation in research. It was the top authority in war-time science, and was an office outside the Military Departments, but in close liaison with all of them. The main reason for its success was that it had both the authority and the funds. It could initiate and control research—something woefully lacking today, even in an office as high as the Assistant Secretary of Defense for Research and Development. As the OSRD came up with new devices or ideas, it passed them on to the War and Navy Departments, who took the necessary action. But the important point was that the OSRD did not have to consult with the various military branches to find out what projects it might investigate.

The OSRD ceased operations in 1946, and all the unfinished work was turned over to the Army and Navy, and what later became the Atomic Energy Commission. The group arguing against civilian control of military research claims that a civilian-type OSRD would not work under peacetime conditions, and that the only reason it did work was because of the emergency conditions of World War II.

MILITARY OPPOSES NOVEL IDEAS

But is this the reason? The military man is, by nature, opposed to any radical or novel ideas for tactical use, as the OSRD found out when it presented its ideas to the various branches of the Armed Forces. The story goes that the files of OSRD are filled with statements from high military authorities concerning these "stupid" and "ridiculous" ideas, which undoubtedly would not have been given a second thought had the military been in charge. In one case during the war, the Navy dropped its interest in a certain OSRD development, since from the Navy's viewpoint it would never have any tactical use. This same development has since become the backbone of naval tactics, and was recognized as such as soon as it was demonstrated. Another situation concerns the Navy's night-fighter designed to operate from carriers. This too was considered ridiculous until shown to be possible. Back in 1939, the study of the proximity fuse was also resisted, because it was thought to be impractical.

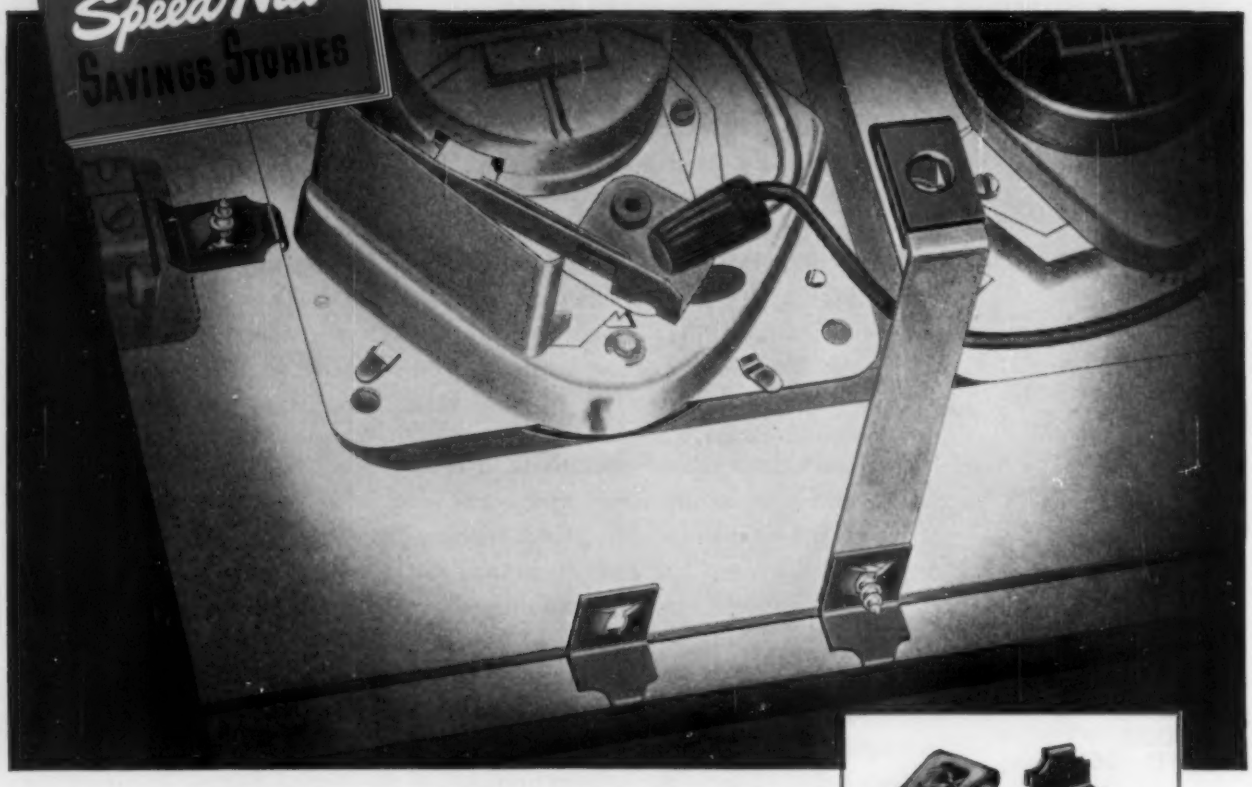
The latest, and perhaps the most classic example along this line, is how the Air Force opposed the Continental Defense problem, which concerned the Distant Early Warning Line (DEW) in the far North. The Air Force was against this plan for three years, and did everything possible to hold it up. The reason for this was revealed in the Oppenheimer investigation in testimony by David T. Griggs, former Chief Scientific Advisor to the Air Force. Griggs said that he and other Air Force people, including then Sec. of the Air Force, Finletter, were afraid that the results of the DEW study might "get out of hand." He meant that if the results of the study were favorable, they might get to the National Security Council, and consequently out of the hands of the Air Force. Thus, if research found this type of defense effective, the Air Force might not get funds for all the planes it deemed necessary. To an Air Force man, interested only in terms of offense, this was unthinkable.

FASTEST THING IN FASTENINGS®

TINNERMAN

Speed Nut

SAVINGS STORIES

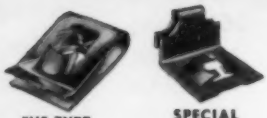


Stove builder cuts assembly time 50% with SPEED NUTS!

Almost unbelievable savings in time, material costs and handling can be gained when an assembled product is designed with SPEED NUTS in mind. Here's proof. Engineers of the Gaffers & Sattler Division, Utility Appliance Corporation, Los Angeles, selected seven different types of SPEED NUT brand fasteners to make almost two dozen attachments on their new gas range. "We are realizing savings of from 30 to 50% in production time over other fastening methods as well as a 25-30% reduction in costs", they report.

In addition to the "U" and special "J" type SPEED NUTS in the rear panel installation shown above, SPEED NUTS also fasten the back shields, top burner supports, griddle cover guide, door hinges and thermostat element.

Your Tinnerman representative can help you locate similar savings in your own product assemblies. Call him today for complete details on our Fastening Analysis Service!



"U" TYPE SPECIAL "J" TYPE

SPEED NUTS

are one-piece, self-locking spring steel fasteners . . . self-retained in screw-receiving position for faster, easier assembly in blind locations. Available for a full range of screw sizes and panel thicknesses.

Write today for your copy of the new Tinnerman Fastening Analysis Service Bulletin No. 336: TINNERMAN PRODUCTS, INC., Box 6688, Department 12, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners, Ltd., Hamilton, Ontario. *In Great Britain:* Simmonds Aerocessories, Limited, Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A.—7 rue Henri Barbusse, Levallois (Seine).

For Welfare or Destruction

UPON COMPLETION of a quarter century of operation it is customary for a publication to celebrate the occasion by a "Silver Anniversary" number of some sort. Such a number might present a chronological history of the publication, which would be interesting to the publishers but hardly so to the readers. Or the editors might give a snappy review of the engineering design developments during the twenty-five years of its existence. But, that would be all old stuff, "water over the dam" and boring reading to most designers. After all, on a 25th anniversary one should not be old enough to dream. To the contrary, one should aim to be always young enough to see visions.

After much pondering, the editors of *Product Engineering* decided on what is perhaps a rather unusual type of silver anniversary feature, "Science and Engineering—Today and Tomorrow". In this article we suggest visions of the world of tomorrow on the basis of the realities of today.

The article also implies man's fate if he fails to control the greater power that his increased knowledge has given him. It can be used for either the welfare of humanity or its destruction, but not for both. Which will it be?

The realities of today are not a sure basis for envisioning the world of tomorrow. History has demonstrated that fact repeatedly. "The Rise and Decline of the ———Empire". The names of many different nations, throughout the ages, can fittingly be put in the blank space. And the same sun that shone on Tyre, Acre and Sidon, still shines upon this earth.

Wealth and power breed self-satisfaction, indolence and an unearned sense of superiority. Oliver Goldsmith in his "The Deserted Village" describes beautifully but sadly the downfall that too often accompanies prosperity.

"Ill fares the land, to hastening ills a prey,
Where wealth accumulates and men decay."

That couplet is applicable to all organizations of humans including business enterprises as well as nations.

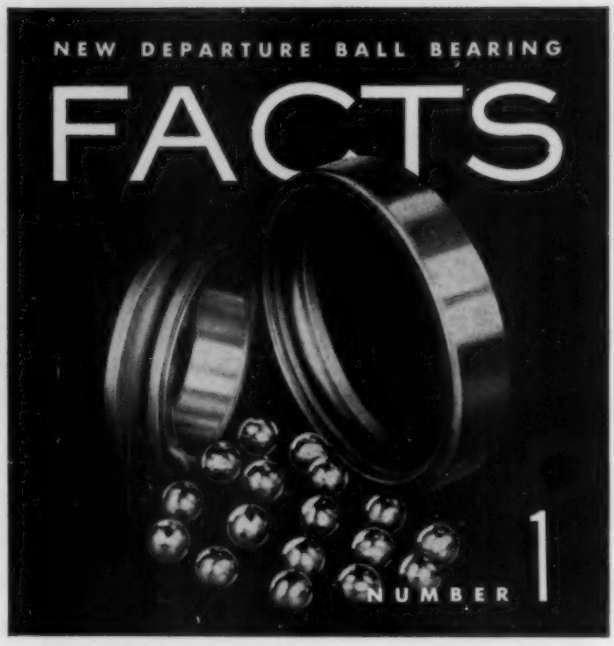
Every new achievement of science has increased man's welfare of living, his power to do good, and also his power to kill and destroy. Have man's moral and spiritual values kept pace with his growing power? The answer to that question will determine whether tomorrow will see the fulfillment of the visions suggested by the scientific achievements of today or whether science today is but forging weapons that will end this civilization and plunge the world into another Dark Ages, but one that will be of much longer duration.

Should this last occur, the blame will not be on the shoulders of science and engineering for having developed the weapons, but will have to be charged against highly educated peoples who failed to heed teachings twenty centuries old.

George F. Bodenschatz

PRECISION SOLUTION

to combination loads!



Combinations of axial and radial loads on moving parts present a constantly recurring problem to the engineer and designer. And this problem is further multiplied by today's demand for lasting precision with minimum service and adjustment. Naturally, too, every designer strives for a basic simplicity in his product that means manufacturing economy.

A Job For Bearings

The work of holding moving parts in a predetermined position or location must fall on the bearings. How well they maintain the desired accuracy . . . and for how long . . . determines their value.

Because of certain inherent qualities, ball bearings offer outstanding advantages that can be found in no other type of bearing.

Basic Advantages Of The Ball

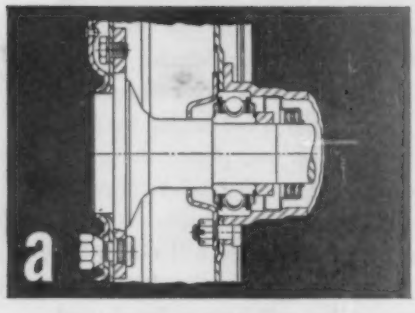
The ball is a unique shape. It rolls naturally in any direction. It has no weakest point. In combination with raceways of proper design, it can resist all loads.

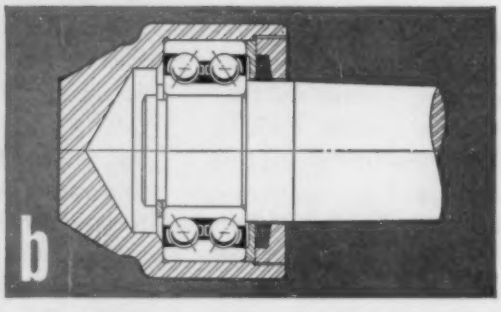
Parts are held rigidly in position and, since wear is virtually nonexistent in properly enclosed ball bearings, no adjustment is required. Regardless of the angle at which load is applied, a uniform and readily calculable resistance is presented, and bearing life may be accurately predicted. Ball bearings thus may be readily selected to match the service expectancy of the machine in which they are used.

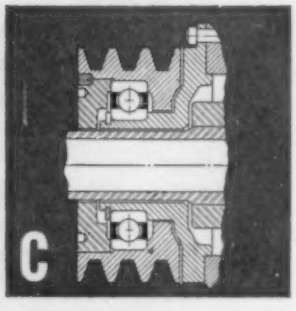
New Flexibility For Machines

Through this ability to resist all loads, machines using ball bearings can be operated in any position and at high or low speeds. One compact ball bearing can often replace an installation of two other bearings of different load-carrying abilities.

New Departure will welcome the opportunity to work with you on any bearing problem. Remember, there is no substitute for experience—and for more than 50 years New Departure has led in bearing design, testing and manufacture.







A. In this automobile rear wheel mounting the axle shaft is located against thrust in both directions by a single New Departure Sealed-for-Life bearing. Adjustments and need for relubrication are eliminated. Here are definite advantages over other types of anti-friction bearings.

B. In applications subject to heavy thrust, such as live centers, double row New Departure *ball* bearings give excellent performance. These bearings may be internally preloaded for maximum resistance to deflection under load. In this example, the center nose is ground after assembly.

C. In applications such as pulleys, New Departure radial, non-loading groove bearings may be used singly for radial, thrust or combined loads according to rated capacities. Thrust and radial capacities are approximately equal.

For complete information send for Booklet BA-2

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BALL BEARINGS

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NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Product Engineering presents . . .

Science *and* Engineering

Today *and* Tomorrow

Past and present scientific achievements that are the tools by which engineers develop the products and machinery for prosperity, well-being and security.

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SCIENCE–

From Ancient Day to MODERN Times

Rome In Its Glory Bettmann

THROUGHOUT HISTORY, the urge to conquer and the necessity to defend has been man's most powerful stimulus for scientific discovery and the material development of civilizations. In ancient times, scientists were the proteges of kings and emperors, while the engineering of structures and machines was sponsored by the military, who judged the value of a new discovery in terms of its utility as a weapon of war, its power to kill and destroy, and its promise of quick victory. Scientists and engineers in the employ of government developed atomic energy.

Rome, greatest conquering nation of early history, was the first to fully exploit the arch, built amazing bridges and highways, and developed aqueduct systems to supply cities with water from reservoirs. That same nation also developed superior weapons of war, and produced them in abundance. The armies of Rome overwhelmed most of the then known civilized world.

One of the by-products of Roman military might and conquest was prosperity. Arts and literature flourished. The sports, feasts, baths and revelries were conducted on the grand scale. But with victory came luxury, to sprout the seeds of decay. The glories of Rome steadily declined and finally vanished. With it went the civilization of the time. The Dark Ages followed.

For a thousand years Europe existed in almost complete ignorance. In the 17th century began the age of reenlightenment. Although every civilized nation of that time contributed to the swelling fund of scientific knowledge, England outstripped all others in number and brilliancy of scientists and the value of their work. Germany was England's closest competitor in the development of science.

From the history of scientific and engineering achievements in England and Germany can be learned a great lesson. Both nations encouraged scientists, supported them, and provided them social recognition and prestige. Royalty came to hear Faraday lecture. In Germany, college professors and scientists were supported by the state and their social status was close to that of the nobility.

In engineering, however, England and Germany differed. In Germany the engineer was accorded the same social level as the teacher and scientist; in England he was relatively ignored. The German state inspired and sponsored engineering achievements. England did very little or nothing in this respect. Germany forged ahead of England in engineering. German engineering defeated England in the battle of trade and commerce, England's life blood.

In the world wars to follow, German engineering produced many weapons distinctly superior. In World War I, "Big Berthas" crumbled French fortifications, long range guns bombarded Paris, and German small arms and artillery proved the better; while in World War II, it was jet propulsion and guided missiles to furnish testimonial to Germany's engineering superiority. The Germans knew the power of science and engineering working as a team.

A New Nation Appears

Meanwhile, the United States of America had come into being. In its early pioneering days, the immensity of the land, the hard tasks confronting the people, and the personal privations challenged the ingenuity of the people to find ways of easing burdens, increasing rates of production, speeding communication and transportation. The people became a nation of inventors. The cotton gin, the reaper, the combine, the sewing machine, telegraph, telephone, steamboat, electric lamp, phonograph, typewriter, automobile, airplane and radio were invented by Americans to fill pressing needs or to satisfy unquenchable ambitions. In the same spirit, the nation organized and operated the greatest science and engineering team the world has ever seen, and produced the atom bomb.

The U. S. A. is now the richest and perhaps most powerful nation in the world. Built by engineering, it has an industrial machine that is incomparable. Luxuries are enjoyed by practically everyone. The accumulated national wealth is at a staggering figure as is the annual national production of goods and services. But in terms of new scientific knowledge, the numbers of scientists and

productivity, the United States is relatively a pauper. For its pure science it has depended on Europe, now in a decline in the production of new scientific knowledge.

What does the future hold? Is the United States about to begin a decline? Are the powers of deterioration going to prevail? Are the seeds of decay sprouting? Historically, such has been the road taken by nations steeped in the conceit of victory and decading under the influence of prosperity. Will history repeat itself? There are strong indications that this will not happen in the foreseeable future.

As the military victor, the United States of America holds many obligations, to fulfill its international responsibility. It must now build, and with dispatch, a strong scientific body and a philosophical leadership capable of taking hold of the reins relinquished by Europe. It is essential that there be nurtured in the U. S. A. an "aristocracy of brains," to take the initiative in the development of the arts and sciences. This "aristocracy" should be awarded the social and political recognition and status such leadership deserves.

The U. S. A. has been benefiting from an influx of foreign scientists and philosophers. But the country must also develop its own. The honors and rewards bestowed on scientists must be such as to stimulate brilliant youths to undertake the labors and sacrifices necessary to attain intellectual accomplishment.

The world is now at or near the peak of an era known as the electrical age. Out of the simple experiment and astounding discovery of Michael Faraday, the generation of electrical energy by magnetic induction, has come a multitude of new products and luxuries. Most of these were far beyond the imagination of the most optimistic dreamers of Faraday's time. Today they are all taken for granted.

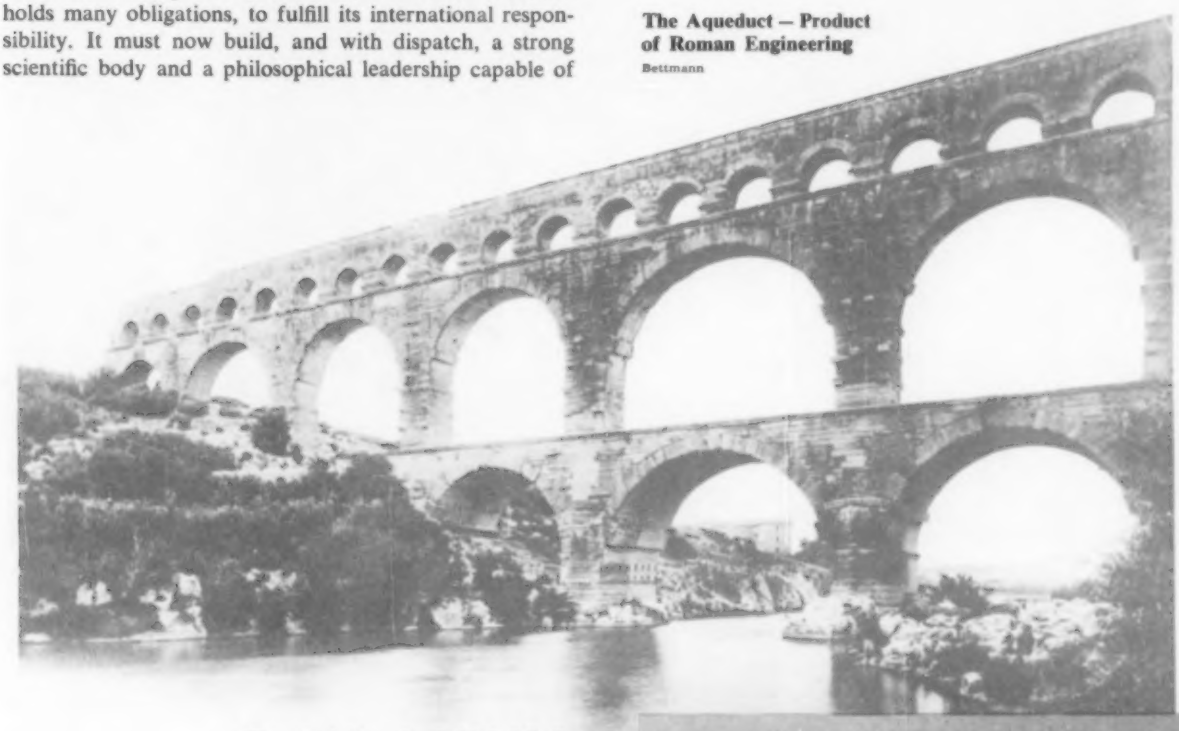
Are we now started on another great era wherein atomic energy will, like electrical energy, be the source from which will come the new products and luxuries undreamed of today?

History says, "Yes!"

For such an era, the United States of America must prepare. Growth and continued leadership in the Atomic Age can be achieved only through national recognition of the place and power of the world's greatest force for progress, the team of Science and Engineering.

The Aqueduct – Product of Roman Engineering

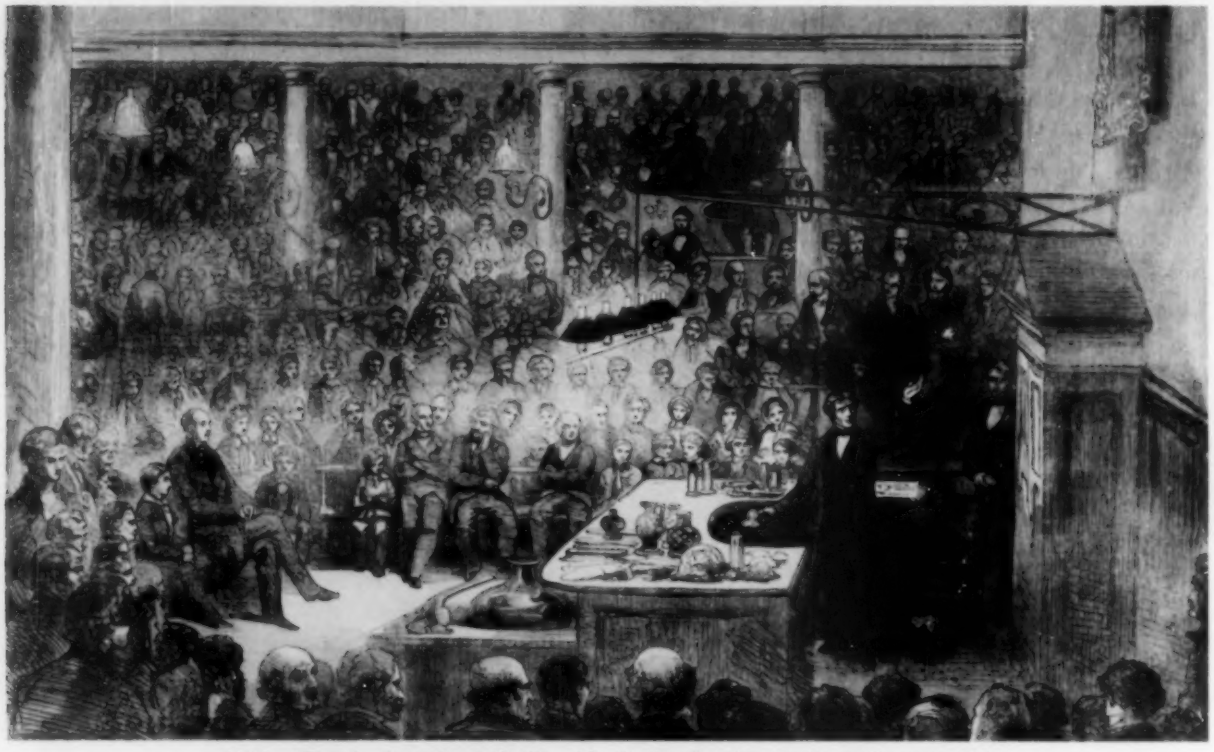
Bettmann



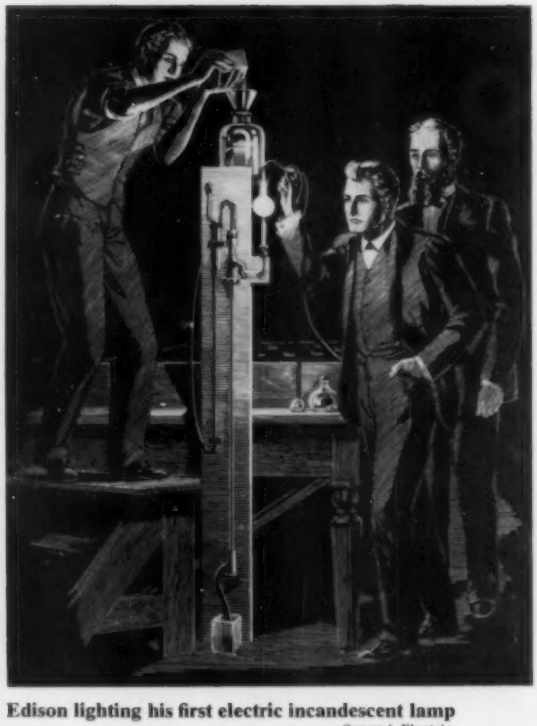
The Anti-Aircraft Guided Missile, White Sands Proving Ground, N.M.

U. S. Army Ordnance

From Faraday's Basic Discovery



Michael Faraday lecturing at the Royal Institution, London. In the audience are His Royal Highness Prince Albert, the Prince of Wales and Prince Alfred Bettmann



Edison lighting his first electric incandescent lamp
General Electric

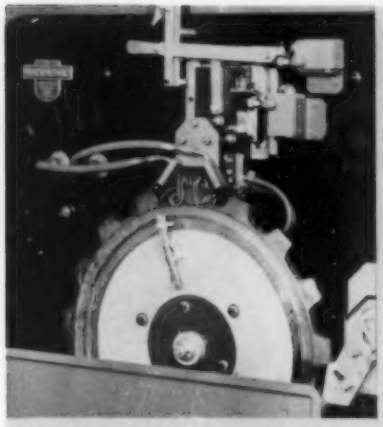
ENGLAND in the 19th century outstripped all other nations in the number and brilliancy of scientists and the value of their work. Lord Kelvin formulated the second law of thermodynamics. James Clerk Maxwell investigated the kinetic theory of gas and discovered the likeness between light and electro-magnetic waves. But it was Michael Faraday's discovery that the cutting of magnetic lines of flux generated electricity which gave the world the basis for the electrical age.

Here is shown Michael Faraday lecturing before the Royal Society. His outstanding humor and his ability to present complicated scientific facts and relationships in a simple and easily understood manner made him the outstanding lecturer of his day. Royalty flocked to hear him and found great satisfaction in witnessing his simple experiments and his even simpler explanations of the phenomena observed.

Faraday's discovery of generating electricity was considered primarily a useful tool for the transmission of energy and as a source of heat. It was only 75 years ago that Thomas Edison succeeded in inventing the filament lamp and thus paved the way for the tremendous industry of electric lighting.

Since Edison's discovery electricity now serves mankind in countless ways and enters into practically every phase of our living – light, heat, power, transportation, medicine, surgery, communications and other services.

. . . Came an Endless Variety of Products



Induction heating Induction Heating Corp.

Radar U. S. Navy

Dielectric heating Westinghouse

Automatic Office Control IBM

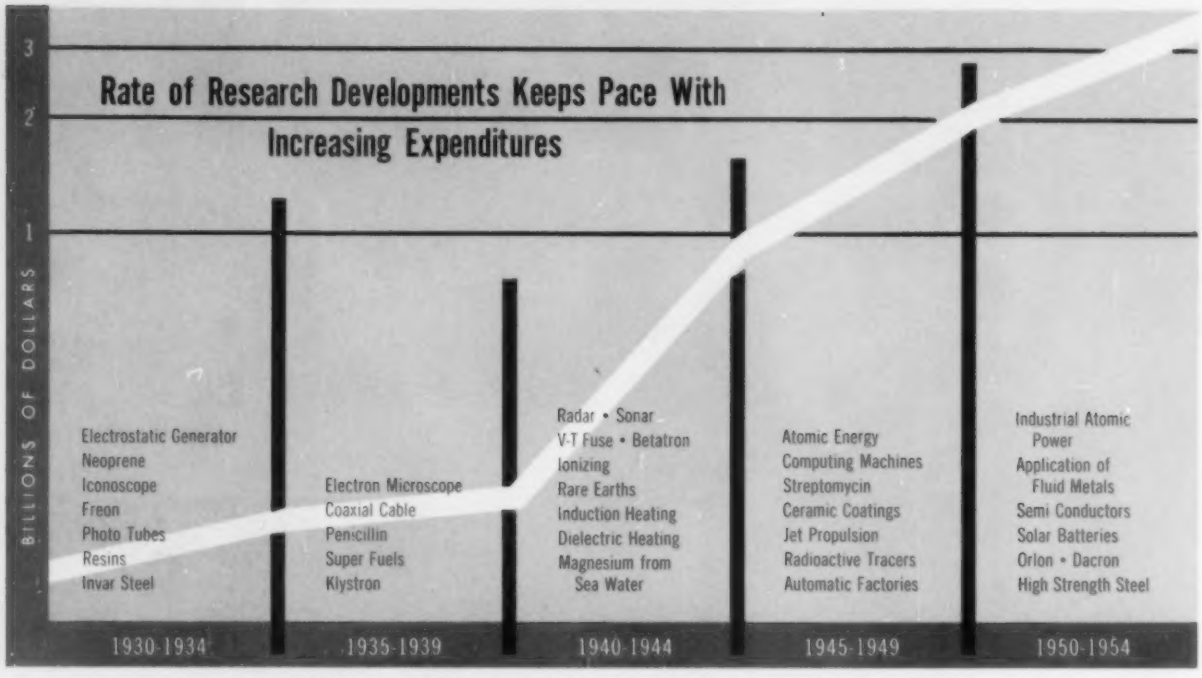
High Speed Telegraphy Western Union

Oscilloscope Du Mont

X-Ray unit General Electric

Portable welder Westinghouse

Growth of Research in U.S.A.



AVERAGE ANNUAL EXPENDITURES OVER FIVE YEAR PERIODS

IT IS ESTIMATED that from 1776, the beginning of the United States of America, to the year 1948, a period of 172 years, this country spent $16 billion on research. The same amount of money, $16 billion, was spent on research in the five years between 1949 and 1953.

In the 19th century, industrial progress relied on the work of the individual inventor. The telephone was developed by a teacher of the deaf; the telegraph by a professor. In the 20th century, the inventor's workshop was replaced by the scientific laboratory.

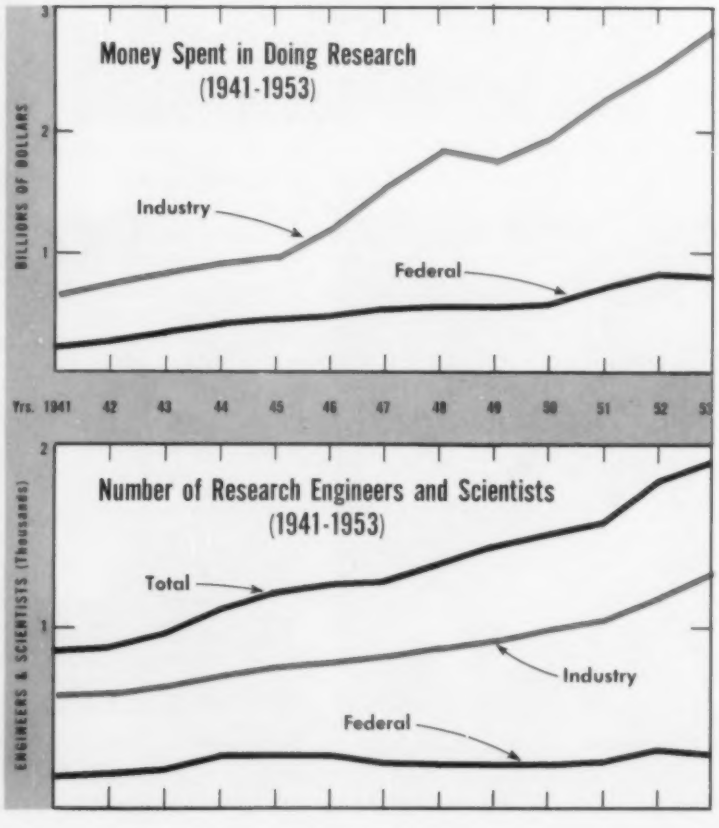
In 1954, research expenditures totalled over $4 billion. Trends indicate in 1965 the national research expenditure should reach $13 billion.

Over the last twenty-five years research has yielded atomic power; the semi-conductor and radar; soil conditioners, ultrasonics and automatic control; jet propulsion; synthetic rubber and high octane fuels; plastics, man made fibers and anti-biotics.

What is on the research agenda? Industrial applications of atomic power, of course. The potential of the solar battery. Increasing conversion of low grade ores into high grade metals. The automatic factory and office. More food, better health and a more "abundant" life for all.

The scientist and engineer of 1980 will consider the 1955 boundaries of knowledge and states of the arts indeed elementary.

Such progress is contingent on an adequate supply of scientific manpower. Is our educational system in gear to produce that need?



New RESEARCH LABORATORIES
Bespeak Industry's Faith in the Value of Research

RCA Research Center, Princeton, N. J.

General Electric Research Center, Schenectady, N. Y.

Esso Research Laboratories, Linden, N. J.

Burroughs Research Laboratories, Paoli, Pa.

For Three Research Centers Tomorrow is Almost Here . . .

IBM Research Center, Poughkeepsie, N. Y.

Monsanto Research Center, Springfield, Mass.

Westinghouse Research Center, Churchill, Pa.

TITANATES • CERAMELS • OXIDES • CRYSTALS

Developments in Metals

ALLOYS MIXTURES COMPOUNDS / forecast new design

THE MOST COMMON PROBLEM in design is that of materials. The all-metal airplane would not be possible without a lightweight high-strength material like aluminum. Moly steel advanced the design of high-pressure vessels operating at high temperature. Stainless steels paved the way for much of the corrosion-resistant chemical equipment. Materials are the most common limitation governing design progress.

For many years science has been seeking the answers to such questions as: Why does carbon and certain other alloying elements make steel stronger? What explains the increased strength resulting from heat-treatment? What in detail are the changes in atomic structure that result in increased elasticity, higher impact strength, greater toughness, or any other property improvements? Why does a trace of impurities, as little as one part in ten billion, drastically alter the electrical properties of germanium or silicon? A teaspoonful of boron in a ton of steel greatly enhances its properties, a pound of it would make the steel all but worthless. Why?

If science could find the answers to these questions it would be possible to compute the properties of an alloy without even making a sample. As it is, it is now necessary to make samples and put them through long series of tests.

As pointed out by Dr. John A. Hutcheson, vice president in charge of research at Westinghouse, to find out all about the properties of all the possible six-element ferrous alloys obtainable when changing the percentage of each constituent in steps of one-hundredth of one per cent, over the range from zero to 5 per cent, would require millions of billions of samples. To put each composition through a complete series of tests would take years. The task would be impossible to complete in several generations.

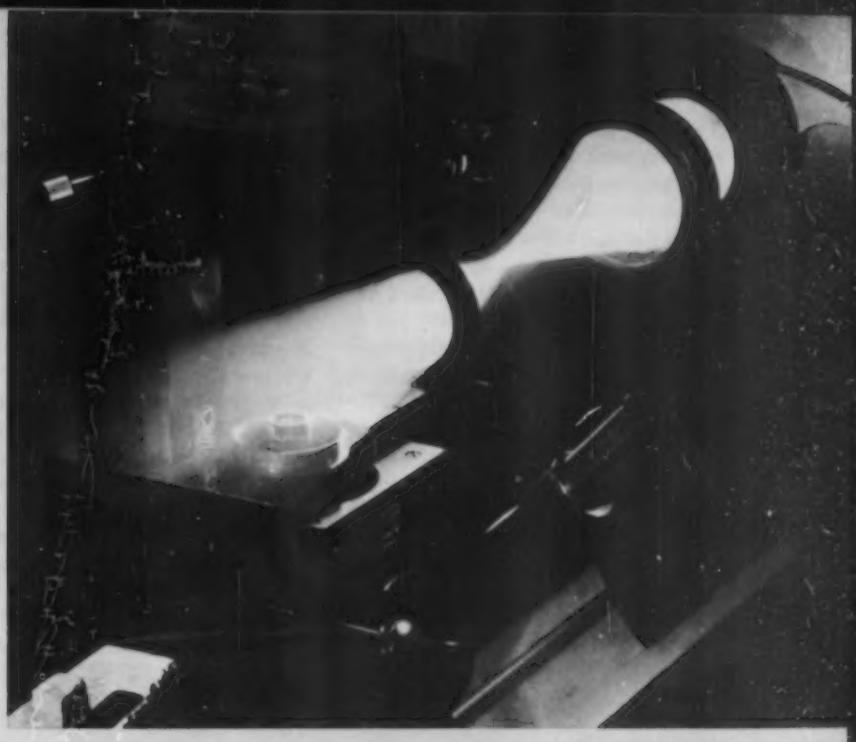
Today metallurgists have merely skimmed the surface in the search for new materials, new alloys, new heat-treatments and new processes. Atomic energy is not yet a decade old but already by the application of irradiation the properties of plastics have been altered remarkably. Vacuum melting is producing new alloys of unusual purity and properties. By a process of freezing out the impurities, metals such as germanium and silicon are made to contain such a small amount of impurity that it cannot be detected by chemical analysis.

Titanium has been holding the spotlight in the field of metals. It is the most satisfactory metal for guided missiles because of its high strength at temperatures up to 800 F, its lightness and its corrosion resistance. The cost of the sponge is still in the neighborhood of $5 per pound and as long as its production requires the consumption of magnesium, there is little chance of an appreciable cost reduction. Titanium reduction presents a difficult problem. In the molten state it reacts with anything other than helium and argon.

But scientists and metallurgists are hard at work trying to develop electrolytic and other methods to reduce titanium from its oxide more cheaply.

One is reminded that twenty-cent aluminum once cost dollars per pound. There are encouraging developments that scientists will not talk about, but just as the cost of aluminum was reduced to a level that permitted its general use, so will the cost of titanium be reduced.

Much work is now going on in researches on the "rare earth" metals with reference to their effects on the properties of steels. It seems that just as the soil must possess traces of many elements to make it best for growing good crops, so is it that traces of alloy additions impart superior properties to some of the ferrous alloys. Traces of cerium or lanthanum added to austenitic steels gives castings with greatly refined grain structure and higher ductility and toughness. Scientifically, the reason is not known but as the science of "physics of the solid state" progresses many of the mysteries of metallurgy



The photo-micrograph at the American Brake Shoe Company used to investigate the composition of metallic grain structures.

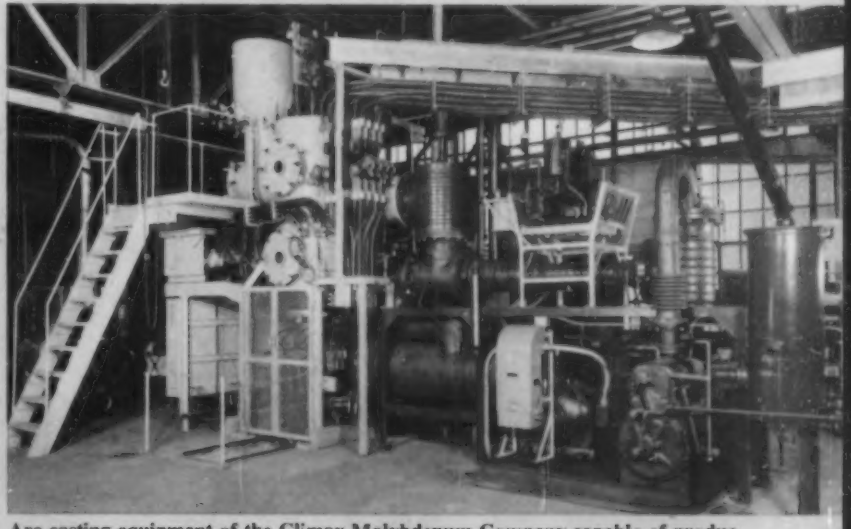
possibilities

will be clarified. It is already established that the emission of electrons, their presence in quantities smaller or greater than required for equilibrium, and many of the fundamentals that prevail in nuclear physics and atomic energy are factors that determine the properties of materials.

Ceramics possess relatively good properties at high temperatures up to 2,000 F. But the material is brittle and has little or no impact strength. On the other hand, some metals have little strength but are quite ductile at high temperatures. Would an intimate mixture of the two result in a material possessing the sum of the properties of the two components? Not quite. But in the cermets or ceramels we have bonded mixtures of metal and ceramic that have extraordinary properties at 2,000 F. Fine powders of the constituent materials are mixed, compacted and sintered in a manner similar to conventional powder metallurgy processes.

How far it will be possible to go with ceramels is impossible to predict. But it is certain that ceramels have opened the door to a vast new field of materials that are basically materials mixtures as contrasted with alloys. There is nothing new in the idea of using mixtures of powders to produce a material possessing the distinct properties of all the components of the mixture. That is demonstrated in the

Titanium in mass production. Chlorinators shown here at the Titanium Metals Corporation of America plant, Henderson, Nev., produce titanium tetrachloride from titanium oxide. From the chlorinators the tetrachloride vapors go to purification units.



Arc casting equipment of the Climax Molybdenum Company capable of producing ingots of up to one ton.

graphite-bronze oilless bearings. The ceramels have simply given a tremendous impetus to further developments in this direction. The need for materials that can withstand the temperatures developed in jet engines and gas turbines is causing a concerted research effort in that direction.

Most promising of the solid metals and alloys for high-temperature work is molybdenum.

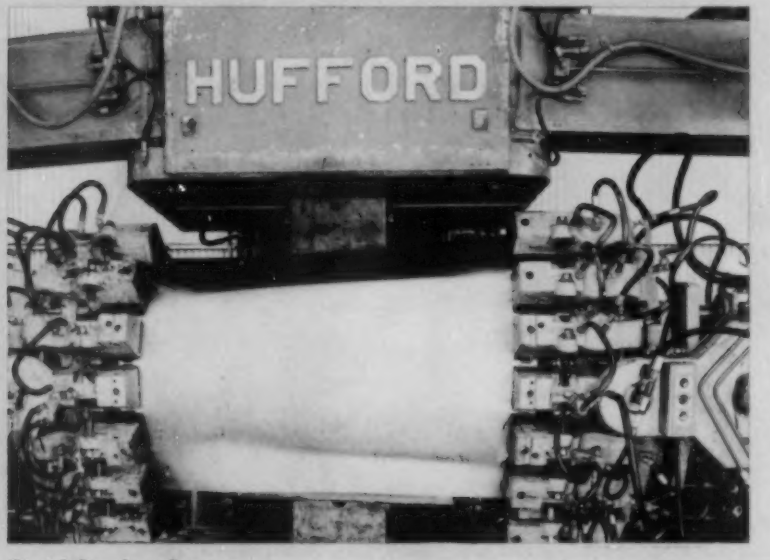
More strength is always being demanded of materials of construction. Today 200,000 lb per sq in. is about the highest ultimate tensile strength obtainable in cross-sections of the order of square inches. Armour Research Foundation, working under a contract from the Ordnance Corps, reports developments of a new titanium alloy with a weight 60 per cent that of steel and 192,000 lb per sq in. tensile strength. But there is clear proof that four times this strength is not impossible. The only question is to find out, as stated above, how and what makes a material strong.

A glass filament has a breaking strength of more than a million pounds per square inch. Fine wires less than 0.001 inch diameter have a breaking strength of the same order. But as the diameter of the wire or filament increases, unit strength decreases. Why? Science is searching for the answer and when it is found, and it undoubtedly will be found, materials of a million pounds per square inch strength and comparable elastic modulus will be produced.

Single Crystals

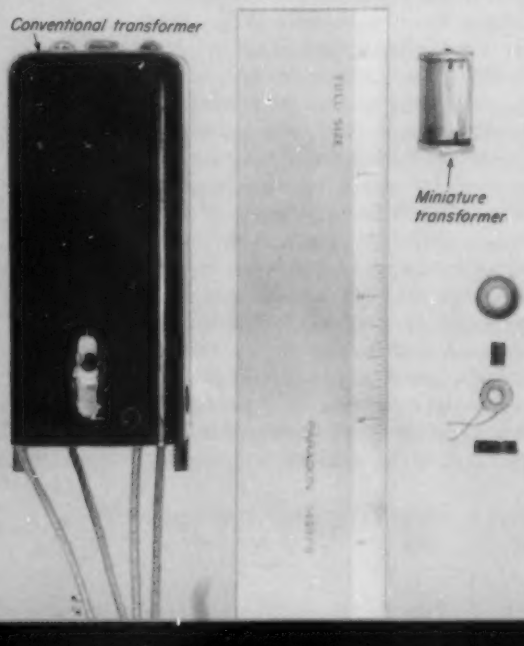
One of the fascinating developments of modern times is the production of single crystals of large size. The process itself is simple. Merely a single speck of the material is suspended in the molten metal and is slowly withdrawn as the crystal grows. The resulting crystal is purified, contaminated to a predetermined slight degree and then sliced and shaped to suit. The final result may be a transistor, semiconductor or solar battery, as will be described in the section of this article devoted to electronics. Here again is a new path of science about which no one can make predictions. The immediate applications of the crystals are only a small segment of the possible developments stemming from this new art and science. It has already initiated a new method of determining almost infinitesimally small amounts of impurities, namely, by the electrical behavior of the metal as a transistor.

Single needle-like crystals of iron are being produced in the research laboratory of the General Electric Company. As explained by Dr. John Les-



Stretch forming a fuselage skin of commercially pure titanium at room temperature at the North American Aviation plant, California.

An iron "whisker" prepared in the Metallurgy Research Department of the General Electric Research Laboratory is shown beside a human hair. The whisker, a perfect crystal of iron, has been found to be many times stronger than any metal or alloy. If it were an inch thick, it would support a weight of nearly a million pounds. Magnification is about 500 times.



A miniature intermediate frequency transformer. The size reduction and economy of materials results from the use of ferrite core material. The miniature transformer is a product of research at the General Electric Research Laboratory.

chen of that laboratory, these crystals, known as whiskers, may be as much as 1 in. long and in diameter range from 0.001 in. down to diameters invisible to the naked eye. Perfect crystal structures are produced having tensile strengths up to 1,000,000 lb per sq in. However, if some of the atoms are out of their proper place or sets of atoms are missing, or the crystal is imperfect otherwise, the strength of the crystal is greatly less.

Herein is indicated the vision of increasing the strength of metals tenfold.

Also—the more we know about materials, why they fail and how to prevent their failure, the lower the factors of safety that designers can use and hence the smaller and more compact the designs.

Metal Oxides

Oxides of metals, as pointed out by both George Deutsch of the National Advisory Committee for Aeronautics and Prof. Ebert of the Case School of Applied Science, are coming into increasing use in powder metallurgy. Dr. John Leschen of G. E. Research reports that oxides of iron are finding many applications for high frequency transformers and magnets.

Synthetic sapphire, or aluminum oxide, was developed by Linde Air Products Company and has been produced by them for many years. The high hardness of the material and its corrosion resistance make it a natural for use as jewel bearings, thread guides and wherever high wear-resistance is needed. Latest of the expanding uses of sapphire include points for Victrola needles, balls 0.025 in. dia for ball pens, and piping light from high-temperature zones around corners to the temperature recording crystal. This last is a development of the Brown Instrument Division of the Minneapolis-Honeywell Company.

Sapphire, which is a single crystal of Al_2O_3, is one of the most stable metal oxides and is practically inert to most reagents at ordinary temperatures. Even at 1800 F it is inert to a large variety of reagents. Photochemically, sapphire is stable and does not show surface changes. The material has a Young's modulus of more than fifty million, a specific gravity of 3.98 and a hardness of Moh 9. However, its resistance to impact or highly localized stress is lower than most metals and steep temperature gradients in the sapphire must be avoided. Otherwise excessive thermal stresses may develop.

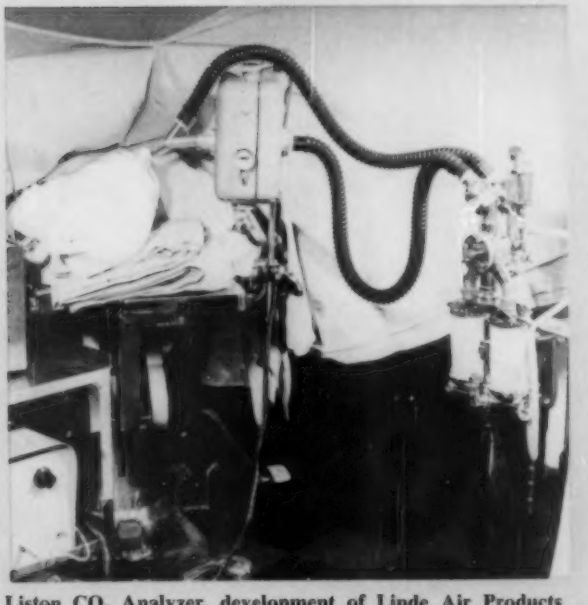
It is of unusual interest that the most startling results in the application of sapphires stem from its optical properties rather than its mechanical properties.

In more recent years the production of synthetic sapphire has made available a material that in sections 2 mm. thick is able to transmit radiations over the wave length range from 0.17 to 6.0 microns. And because the material is physically strong and chemically inert it lends itself to some highly interesting uses.

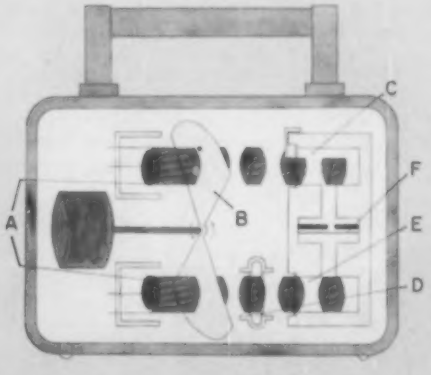
Sapphire disks more than two inches in diameter can now be produced. These were developed for use as windows in optical systems, *primarily because* of its wide transmission band, its high temperature properties and its abrasion resistance. The infrared transmission of sapphire is superior to that of quartz, thereby making sapphire suitable to broader use with photoconductive cells.

One of the most striking applications of sapphire windows in optical systems is in instruments for the continuous recording of carbon dioxide. Infrared light passes through a chamber in which is the carbon dioxide. The light enters and leaves through sapphire windows and then impinges upon a light-sensitive electronic cell. The voltages developed in the cell then record, by means of an electronic system and instruments, the percentage of carbon dioxide in the air sample.

Using these principles and devices there has been developed an instrument which measures spectrographically the per cent of carbon dioxide in the exhalation of a patient being operated upon and under anesthesia. The continuous indication of the car-



Liston CO_2 Analyzer, development of Linde Air Products Company, measures exhalation of carbon dioxide, which during surgery, determines amount of oxygen supplied to patient. The Analyzer employs sapphire windows.



Infra Measurement in Liston CO_2 Analyzer. Infra-red emitted by two nichrome sources (A) is chopped synchronously by mechanical rotation of segmented disc (B). One infra-red path is directly into the reference cell (C); the other path is through the sample cell (D) and into the detector cell (E). Sapphire windows in the two paths transmit infra-red bands which are absorbed by CO_2. Reference cell and detector cell are filled with CO_2 and separated by the diaphragm of a differential capacitance manometer (F). Pressure difference between reference and detector cell is adjusted by a shutter in path of reference cell. CO_2 in sample cell decreases infra-red reaching detector cell and less pressure is applied to the capacitance manometer.

bon dioxide content in a patient's breath gives immediate continuous indication whether more or less oxygen is to be fed to the patient. Thereby the possibility of convulsion, one of the common causes for deaths on the operating table, is averted.

The sensitivity of this spectrographic measurement is such that it can indicate a change of one millionth of a part of carbon dioxide in the sample.

A further use of the same spectrographic instrument outside of the field of surgery is on the *Nautilus*, the first atomic-powered submarine built, for the purpose of continuously indicating the carbon dioxide content of the air in the submarine.

This type of spectrographical analysis is not limited to carbon dioxide. In the production of synthetic ammonia by a combination of hydrogen and oxygen induced by a catalyst, the spectrographical method is used for indicating the proper amounts of nitrogen and hydrogen.

The Light Metals

Inability to withstand high temperature has been a common limiting factor in the application of the light metals, aluminum and magnesium, particularly the latter. J. H. Jackson, manager of the metallurgy department of Battelle Memorial Institute, states that Misch metal, which is a combination of rare earths, and the element thorium, have been added to magnesium. The result is a metal able to withstand 600 F. Aluminum powder coated with its oxide, pressed, sintered and extruded, produces a metal that can withstand well over 600 F without loss of room temperature physicals.

Aluminum is the second most widely used metal and its production is climbing steadily. It is one of the most plentiful known metals in the earth's crust.

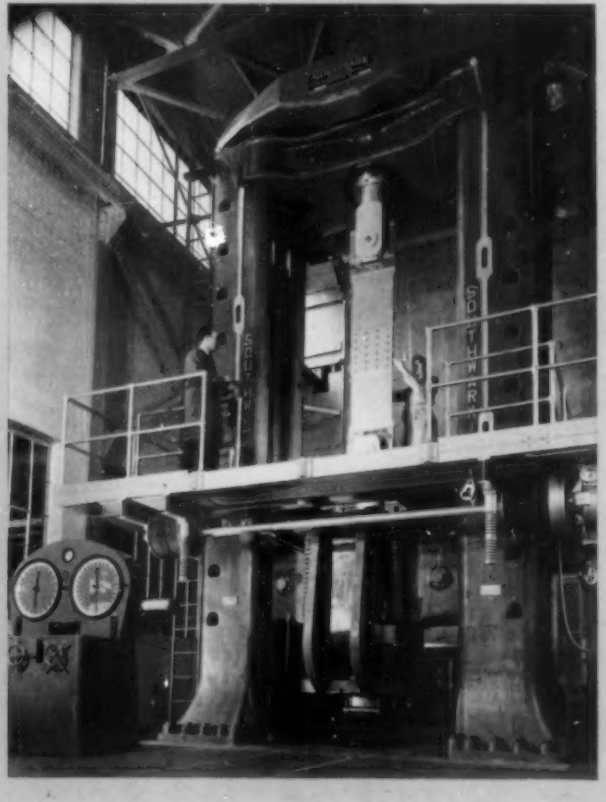
One of the most common contributing factors to reducing the strength of a metal is occlusions of gases. The gas-free metal is more dense and has a finer grain structure, hence better physicals. This is illustrated in the superior physicals of forgings over castings.

There has now been developed a casting technique by which aluminum, and some of the other light metals, can be cast as strong as forgings of the same composition. This is done by getting rid of the hydrogen which is the principal cause for the porosity in the castings. Such castings will cost about twice as much as ordinary castings but may be cheaper than forgings. Where weight reduction is highly valuable, as in aircraft, the hydrogen-free aluminum castings may be far superior and worth more than conventional castings.

Dr. J. H. Jackson of Battelle reports work being done on a new magnesium-lithium alloy series. These alloys are lighter than magnesium, and far stronger and more ductile. But they are more chemically active and more expensive and as yet the high-strength alloys are not stable. However, it is expected that this problem will be overcome.

At the Dow Chemical Company research laboratories at Midland, Michigan, Dr. J. C. MacDonald reports researches to find out why different magnesium alloys have different creep rates. Also under study are problems and possibilities of magnesium-lithium alloys, and investigation of fatigue intergranular and intragranular.

Precision metal-working and testing machine of 3 million pounds capacity, installed at the Aluminum Company of America Research Laboratories, New Kensington, Pa.



Corrosion testing under cyclic stress. Tensions specimens are stressed as simple beams and continuously immersed in a corrosive solution. A dead weight gradually applied and withdrawn stresses the specimens. Equipment shown evaluates combined effects of cyclic stress and corrosion, and is fitted for high temperature studies. The operator at the Aluminum Company of America Research Laboratories is shown lowering in place a fixture including a stressed (upper) and an unstressed specimen.

Unfortunately, the blind application of the universal draft law took away from Dow the specially trained scientist who was making a fundamental study of magnesium grain structure. This all-important project had to be stopped because it would have required two years for a replacement to reach the point to which the man had progressed.

Other studies at the Dow laboratory cover the factors governing crystal orientation, improvement of the compressive strength of the material and its corrosion resistance. A search for inhibitors to arrest galvanic reaction is being made.

Powder Metallurgy

We have mentioned powder metallurgy and the cermets and oxides and other possibilities. The art of powder metallurgy is old. Bound Brook Oil-Less Bearings Company produced powder pressings in 1921. But the possibilities of this art have hardly been scratched.

Mr. G. L. Bachner of Yale & Towne looks forward to a great number of amazing new developments, many of them "just around the corner." New powder pressings "compounds" of ceramics and metals, possessing structural and electrical properties hitherto unknown, especially materials capable of resisting extremely high temperatures.

Metal oxides are just beginning to get important as an engineering material. Metal oxides, principally iron and zinc, with small additions of nickel, manganese, cobalt or magnesium oxides, result in powder pressed materials possessing unusual electrical properties such as extremely high permeability. Similarly, titanates, powder pressings of a titanium base, have been developed for use in capacitors for radio and television receivers.

A reasonable expectation, as pointed out by Mr. Bachner, is ferrite powder pressings, with proper additives, for powder pressed rotors and stators to give small, more powerful electric motors and for lighter weight transformers. Ferrites promise amazing possibilities in miniaturization.

Other powder pressing possibilities are filters of selectively controlled pore size and new types of bearings possessing remarkably low coefficients of friction.

Dr. Fritz V. Lenel of R.P.I. points out some future "things to come."

After several years research at Rensselaer Polytechnic Institute, Dr. Lenel wrote a paper for the Journal of Metals. In it he described a method of hot pressing metal powders by simultaneously passing electric current through the compact and applying pressure; thereby, heating primarily the pressing and not the die. This introduces new techniques in powder metallurgy.

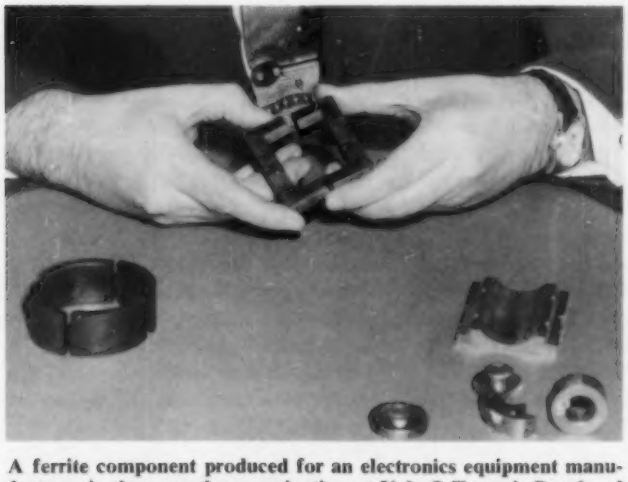
Dr. Lenel has also been active in the development of porous turbine blades made of stainless steel powder. They are cooled by passing air from a cavity inside the blade through their porous walls. This permits more efficient cooling than by convection.

Rensselaer Polytechnic Institute is also working on aluminum-base materials to have good strength up to 750 F suitable for use in guided missiles and supersonic aircraft.

Chemetals Corp. reports the successful completion of research and a start on construction of a plant where copper powder will be reduced from scrap and rolled into strip into a single, continuous operation. Prices of strip made this way are lower than for strip made by conventional means. Research for this was carried out in Germany and, in the U.S.A., by SKC Research Associates, Paterson, N. J., powder metal consultants.

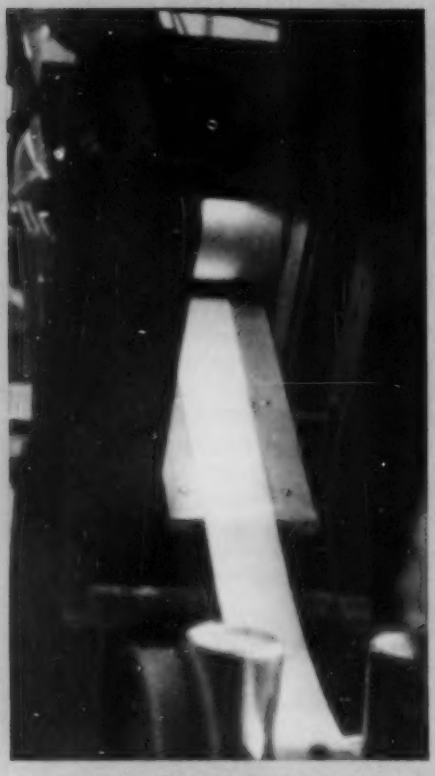
At the NACA laboratory Dr. Robert Lad and his group are working on creep phenomena, attacking the problem from the standpoint of solid-state

ONE-SECOND COMMERCIALS: Cambridge Wire Cloth Co. is reported to be the first in the manufacture of 16 mesh titanium wire screen. . . . Ben Fairless, chairman of U. S. Steel estimates industry will have to spend 300 billion dollars in the next ten years on plant modernization to keep in step with technological progress. . . . Keystone Carbon Company's latest is a high-density alloy-steel powder pressing with ultimate tensile of 115,000 lb. per sq. in.

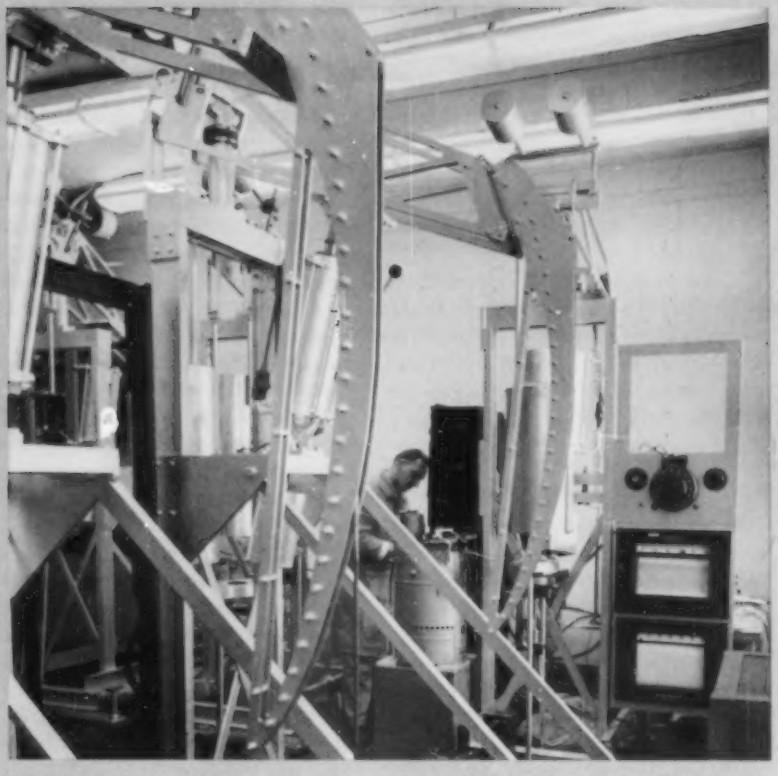


A ferrite component produced for an electronics equipment manufacturer is shown under examination at Yale & Towne's Powdered Metal Products Division.

Research in powder metallurgy conducted in the department of metallurgical engineering at Rensselaer Polytechnic Institute. Dr. Fritz Lenel is shown during a phase of a stainless steel compact sintering process.



A compacting mill used in the experimental rolling of metal powder into strips. In a plant now under construction, copper will be reduced chemically from scrap, and compacted, sintered and hot-rolled into strip in a single continuous operation. Chemetals Corp. expects prices for products produced by their licenses to compare favorably with strip made by traditional means.



Creep Testing. This special equipment in Standard Oil Company's new engineering research laboratories at Whiting, Ind., is used to measure the behavior of steels under high temperature and constant stress.

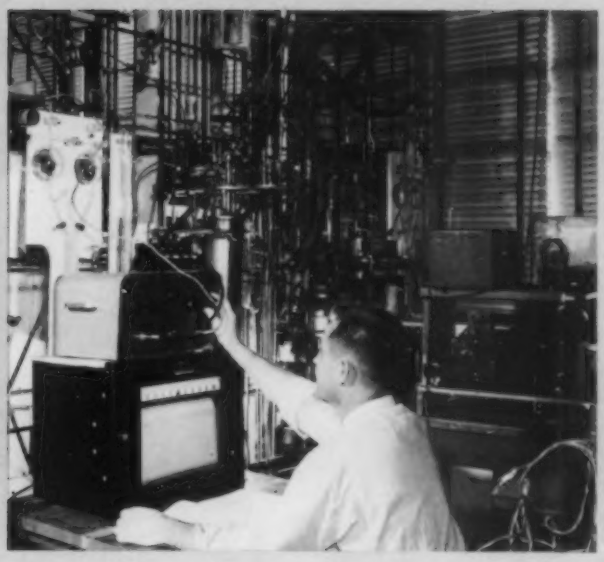
physics. What factors in addition to load and temperature affect creep? Do surface conditions of the loaded member have any effect? Dr. Lad dissolved the surface of a specimen. Creep failure occurred more rapidly. From that it developed that the oxide shell covering the specimen increases creep resistance. Extensive creep testing is also being done at the Standard Oil Co. of Indiana's laboratory at Whiting.

Also at the NACA laboratory, there is being developed a technique for healing atomic and sub-atomic cracks and imperfections of the surfaces of cermets and similar pressed powder materials. The process involves painting, plating, vaporizing and melting. Apparently something more occurs than merely filling the voids. For example, these researchers discovered that cementites migrate from the parent material over into the new "filler" substance. Increases in tensile strengths up to 25 per cent have been obtained by this process for healing cracks and imperfections.

At Ohio State University, Prof. Walter L. Starkey of the Mechanical Engineering Department has been studying the failure properties of metals for the last eight years. One of the things he is trying to determine is the effects of multi-harmonic stresses on cumulative fatigue damage. Prof. Starkey is also studying the fretting-corrosion-fatigue characteristics of titanium-steel joints. Further, he is investigating the fatigue damage accumulated just prior to the development of a visible crack. In connection with the last study, he has developed a thermal method in which extremely sensitive thermocouples are inserted in scratches or minute cracks on the surface of the specimen. Temperature changes indicated by the thermocouple reveal the progress of the crack.

Prof. Starkey also has developed a new hydraulically-operated fatigue testing machine which has been designed and built to serve as a research tool for investigating the effects of multi-harmonic uniaxial stresses on the endurance lives of metals. The machine is capable of inducing in its axially stressed specimens a composite stress pattern, consisting of the superposition of fundamental and second harmonic sinuosoidal stress-time waves. The specimen is stressed by the action of variable hydraulic pressures on a piston to which the specimen is attached. These pressures are caused to fluctuate by the action of cam-operated hydraulic plungers. Control of hydraulic pressures is accomplished by a system composed of three dead weight comparators and a two-cylinder injection pump. The machine has already been used for several series of tests of which the results are scheduled for eventual publication. In general, it has been established that the peaks of a multi-harmonic stress are much more significant than the secondary stationary values.

Also at Ohio State University, Dr. Mars G. Fontana, head of the Department of Metallurgy, announces that studies are being conducted in high strength corrosion-resistant alloys for use in valves and other equipment. Keen interest is being given metals



(Far Left) Continuous casting of steel ingots presages substantial changes in steel manufacture. Here is shown the continuous ingot as it feeds downward. A dual torch system cuts the continuous casting into suitable lengths. Torches automatically clamp on the casting, moving downward with it, complete the flame cut and automatically return to starting position.

(Left) Thermoelectric effects of metals are tested in the range from liquid helium to room temperature at the research laboratory at General Electric. Dr. John Youngblood is shown taking measurements.

that can withstand liquids at high temperatures and pressures. Molybdenum is under investigation because of its excellent high temperature mechanical properties including the modulus of elasticity of 50,000,000 psi. Work is also being done on alloying and coating molybdenum to prevent oxidation.

One of the specific projects is an attempt to determine why titanium resists corrosion. Study is being made on the properties of titanium which make it corrosion resistant.

Another project, under the supervision of Dr. J. W. Spretnak, is concerned with boron's effect on hardenability of carbon steel. Everybody knows that boron hardens steel, but they don't know why; this project is an attempt to determine why boron has a strong hardenability effect.

Interest is centered on the problem of corrosion, from the standpoint of developing corrosion-resistant materials, and to determine exactly what corrosion is, why it happens, why is one material more corrosion-resistant than another. Another facet to the corrosion picture is the study of the effects of compounds on metals. For instance, vanadium is in fuel oil, and vanadium pentoxide deposits on the surface of high strength alloys and results in catastrophic oxidation of the alloy. The causes of such phenomena is the material under study.

In the steel making industry the size of ingot will soon have little or no significance. Following the direction pointed out by the continuous casting process now being used in the brass industry, there has been designed, built and put into operation at the plant of Atlas Steel Company Ltd., in Welland, Ontario, Canada, a continuous steel ingot casting machine.

It is expected that the general adoption of continuous casting of steel ingots will have a marked effect on the economics and procedures in steel making. The cropping of the ingot to get rid of entrapped gases and floating impurities will be a thing of the past.

Because electrical conductivity is such a highly important property, much time has been given to this subject. In general, the electrical resistance of a metal increases with temperature. The electrical resistance of carbon and some other elements decreases with temperature. Why? What happens when temperature keeps on rising? What happens to the electrical resistance if the temperature is decreased to a point close to zero?

In the search for the answer to such questions some extremely interesting facts came to light. When the temperature gets down to the neighborhood of 50 F absolute, the electrical resistance suddenly vanishes. Theoretically, a current in a path of zero resistance would flow forever. Actually, the magnetic field set-up by the current establishes a counter action that stops the current.

Here is an unusual phenomena. Why the zero resistance? What is the inter-relationship between heat energy and electrical energy that causes this strange behavior? Does the approach of zero heat energy bring about some mysterious molecular behavior or arrangement that wipes out all barriers to the flow of electricity? The flow of current through a metal conductor creates heat. Why does the approach of the absence of heat cause the electrical resistance to practically vanish?

What new scientific possibilities and realities will be born when science finds the answers to these questions? Will it pave the way to the transmission of electrical power without losses? Will it become possible to design motors that will have practically no heat losses and the power output of which will be limited only by their mechanical strength? Today such thoughts may sound ridiculous. Tomorrow they may be a reality.

Only the surface of new developments in metals has been skimmed. Basic researches are going on in many laboratories. The answers to innumerable questions are being sought. Why does hydrogen embrittle steel? Why does hardness increase with strength? What is the process of fatigue failure? Why does carbon increase strength or nickel add to toughness? Why? Why?

Like a child seeking light from its parents, the question is Why? Why? And in the answers are uncovered new vistas, new frontiers, new thrills.

Engineers Who Head Some of the World's Largest Industries and Corporations

Men shown here are a few of the graduate engineers now at the helm of large American companies; many businesses have become so highly technical only trained engineers understand important operational problems. Companies represented have a total capitalization of more than $30 billion.

General Motors
Alfred P. Sloan, Jr., Chm of Board
M. I. T., B. S. in E. E.

General Motors
Louis C. Goad, Exec Vice Pres
Univ of Ill , B. S. in M. E.

General Motors
John F. Gordon, Vice Pres
Univ of Michigan, M. S.

General Motors
Carl H. Kindl, Vice Pres
Carnegie Inst of Tech , E. E.

General Motors
Robt. M. Critchfield, Vice Pres
Ohio State Univ , B. E. E.

General Motors
Cyrus R. Osborn, Vice Pres
Univ of Cincinnati, M. E.

du Pont de Nemours & Co
C. H. Greenewalt, Pres
M. I. T., B. S. in Ch. E.

Amer. Telephone & Telegraph Co
Cleo F. Craig, Pres
Univ of Missouri, B. S. in E. E.

Standard Oil Co (N. J.)
Eugene Holman, Chm of Board
Univ of Texas, M. A. in Geology

Standard Oil Co (N. J.)
Peter T. Lamont, Director
M. I. T., B. S. in Pet. E.

Bethlehem Steel Company
E. G. Grace, Chm of Board
Lehigh Univ , E. E.

Aluminum Company of America
I. W. Wilson, Pres
M. I. T., B. S.

Standard Oil Co (N. J.)
M. J. Rathbone, Pres
Lehigh Univ , Ch. E.

Standard Oil Co (N. J.)
Howard W. Page, Director
M. I. T., M. S. in Ch. E.

General Electric Co
Philip D. Reed, Chm of Board
Univ of Wisc., B. S. in E. E.

General Electric Co
Henry V. Erben, Exec Vice Pres
Yale Univ , B. S. in M. E.

General Electric Co
Robert Paxton, Exec Vice Pres
R. P. I., B. S. in E. E.

General Electric Co
Charles K. Rieger, Vice Pres
Univ of Missouri, B. S. in E. E.

U. S. Steel Corp
American Bridge Div
Norman B. Obbard, Pres
Cambridge Univ, B. A. in Mech Sc.

U. S. Steel Corp
Tennessee Coal & Iron Div
Arthur V. Wiebel, Pres
Carnegie Inst of Tech, M. E.

U. S. Steel Corp
Oil Well Supply Div
Fred F. Murray, Pres
Stevens Inst of Tech, M. E.

U. S. Steel Corp
Pittsburgh & Conneaut Dock Co
Keith C. Stevens, Pres
Case Inst Tech , B. S. in M. E.

Socony Vacuum Oil Co
G. S. Dunham, Dir of Mfg
Cornell Univ , B. S. in M. E.

The Dow Chemical Co
Mark E. Putnam, Exec Vice Pres
Univ of Michigan, M. S.

The Dow Chemical Co
Calvin A. Campbell, Vice Pres
Univ of Mich , B. S. in Ch. E.

The Dow Chemical Co
Albert Philip Beutel, Vice Pres
Case, B. S. in Met E.

Radio Corporation of America
V. K. Zworykin, Vice Pres
Brooklyn Poly Inst , D. Sc

Radio Corporation of America
E. W. Engstrom, Exec Vice Pres
Univ of Minnesota, B. S.

Johns-Manville Corp
A. R. Fisher, Pres
Rutgers Univ , B. S. in Eng.

Johns-Manville Corp
C. Rassweiler, Vice Chm of Board
Univ of Ill , Ph. D. in Ch.

Standard Oil Co (N. J.)
John R. Suman, Vice Pres
Univ of Calif , B. S.

Radio Corporation of America
C. B. Jolliffe, Vice Pres
Cornell Univ , Ph. D.

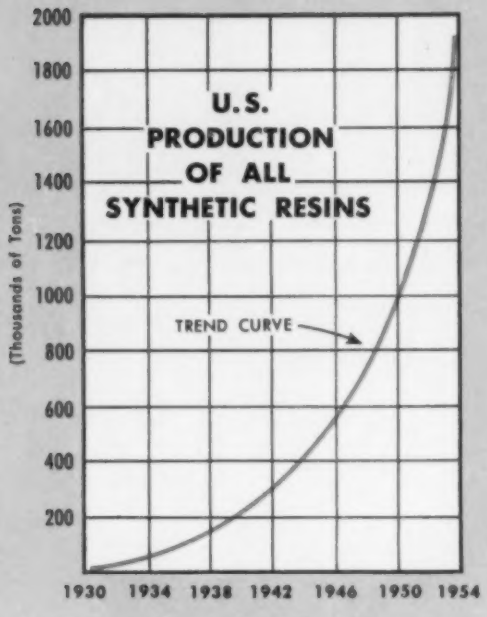
Johns-Manville Corp
John P. Syme, Vice Pres
Cornell Univ , B. S. in M. E.

DuMont Laboratories, Inc.
Allen B. Du Mont, Pres
R. P. I., B. S. in E. E.

New Designs Made Possible by Plastics—

the Materials of Art and Science

Many combinations of properties — 27 basic types — thermoplastic — thermosetting — high strength — light weight — good dielectrics — permanent finish — moisture resistant — non-flammable



PLASTICS

THE WORD "PLASTICS" as applied to synthetic materials is a misnomer. In their finished state, many of the "plastic" materials are brittle. Conversely, many materials possessing a high degree of plasticity would not by any stretch of the imagination be spoken of as one of the family of "plastics." The Germans have a more logical name. What English speaking people call plastics, they call "Kunstmaterial," meaning material made by art, by magic, or by a profession.

Whatever name we give them, the development of these synthetic materials by the science of chemistry has had tremendous effects. Even so, the 27 or more basic types of plastics we have today are but the beginning. Production of plastics has jumped manifold in the last twenty years and, as shown by the accompanying graph, is still on the increase. New plants for their production are being built, many more are planned.

Many of the plastics companies, including Du Pont, Dow, Koppers, Monsanto and General American Transportation Company, are pushing hard the development of combinations of expanded polystyrene for products of complex shape. Waste of material is a minimum.

An overall view of the whole plastics situation is given by A. D. Green of Standard Oil Development Company. As he sees the picture: "Some classes of plastics will continue to grow, others will level off, but overall production will continue to increase." Present indications are: 3.5 billion lb in 1955; 4.8 billion lb in 1960; and 9 billion lb for the year 1975.

The alkyd group is used mainly for paints, varnishes and allied finishes. Spectacular growth in this field is not expected. These are based chiefly on phthalic anhydride and glycerol.

Phenolic plastics have their largest use in molding structural materials, but are also being used for laminating, adhesives and protective coatings. Demands for 1955 are estimated at 850 million lb; 1960 demand at about 950 million pounds.

Polystyrene is one of the most rapidly growing plastics. Principal use is as a molding compound. Styrene is one of the compounds used in the production of synthetic rubber of the GR-S group. Increased manufacture has caught up with the demand. Styrene production in 1955 will be about 1 billion pounds. Estimated styrene requirements for polystyrene plastics are: 1955 about 500 billion lb; 700 billion for 1960; and 1,500 million for 1975.

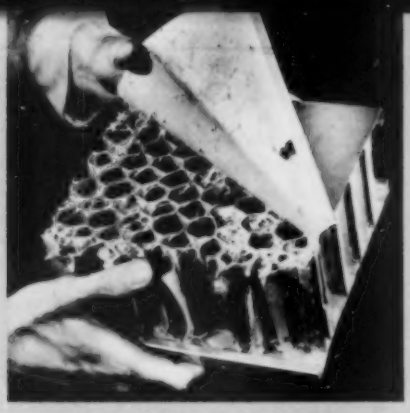
Urea and melamine resins, useful for adhesives, laminating, molding, textile and paper treatment, are following but not as rapidly as the others. Estimated needs by 1960 is 340 million lb; by 1975, 570 million pounds.

The vinyl plastics have been enjoying a phenomenal growth and indications are that the growth will continue. Vinyls cut across many markets such as rainwear, draperies, hoses, records and electrical insulation. Basic raw materials are ethylene and acetylene. Production of vinyl should reach 700 million lb by 1955; 1,200 million by 1960; and 2,000 million by 1975.

New materials for plastic pipe are receiving attention. Unplasticized polyvinyl chloride is a favored material, as reported by Carl Massapust of General American Transportation. But there are difficulties. The material is so highly temperature sensitive that present machinery for molding and extruding cannot be used effectively. New machinery and techniques will have to be developed.

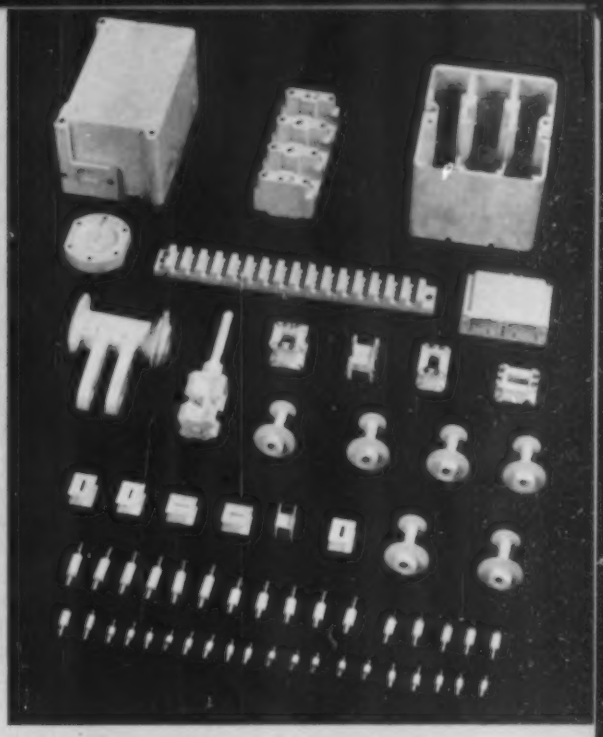
Although still in its infancy, plastic pipe may become the largest single outlet for plastics by 1960, according to Erik R. Nielson of Armour Research Foundation. Furfural alcohol resins have good electrical and chemical properties for pipe materials, and relatively cheap, they can be used for molded electrical parts and coatings on metals for corrosion protection.

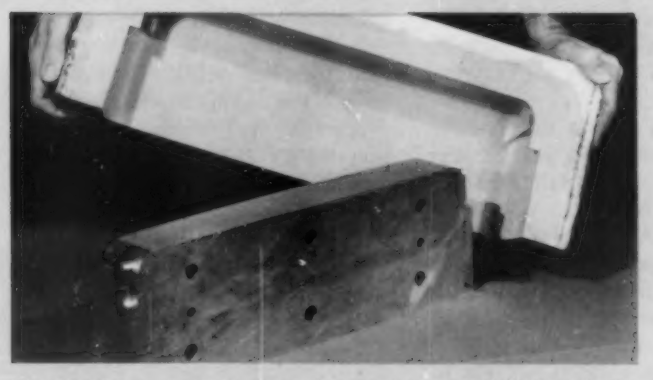
One of the highly promising plastics now in use for pressure piping is the epoxy-glass laminate. Laboratory tests indicate strengths to withstand hoop stresses of 10,000 lb per sq in. at 110 F and 5,000 lb per sq in. at 150 F. Higher strengths are expected.



A three-inch thick honeycomb core made of kraft impregnated with Bakelite phenolic resins is sandwiched between thin aluminum sheet facings, to give pre-fabricated panels high strength with the least possible weight. A solid aluminum sheet as rigid as the honeycomb core panel would weigh ten times as much, according to the manufacturer. The honeycomb core is also said to provide full insulation and resistance to outside temperature at least 30 per cent better than the ordinary frame wall with stucco outside, metal lath and plaster inside.

MELMAC 3135, a glass-filled, electrical grade melamine molding material, developed by American Cyanamid Company's Plastics and Resins Division, is an important achievement in combining plastics and glass fiber. The material offers high strength, excellent arc resistance, high insulation resistance, together with extremely low shrinkage and moisture absorption. At present, MELMAC 3135 end uses are mainly in the electrical field, including heavy duty switch gear, terminal strips and standoffs, sockets and coil forms.

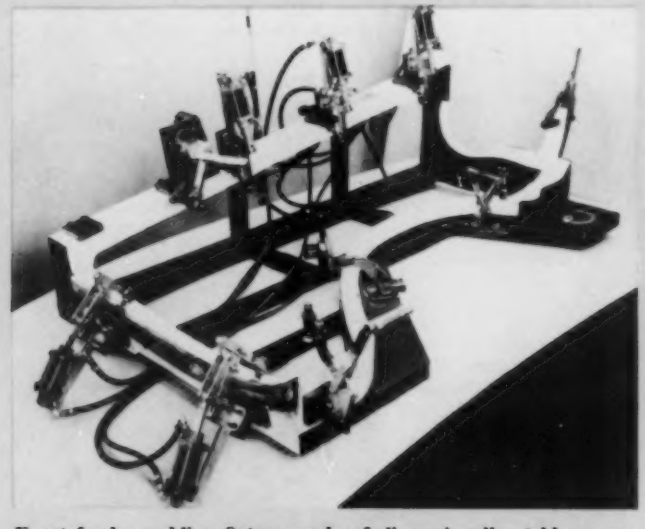




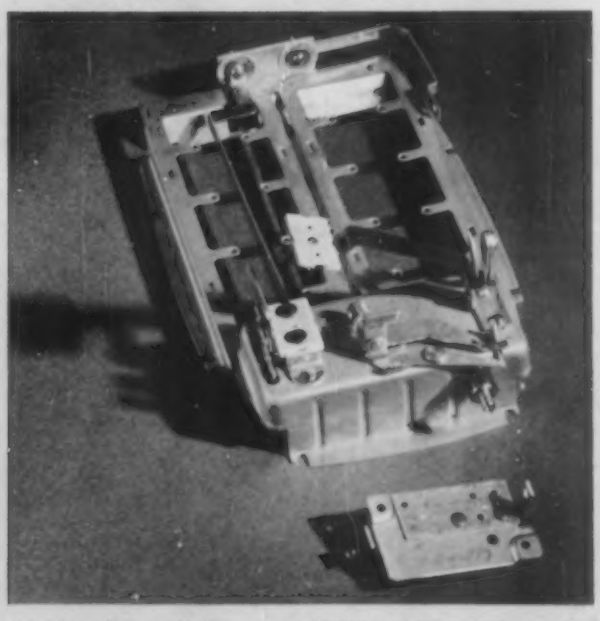
Epoxy resin compounds are used to produce a steel die for plastic injection molding. A model of the concave die face is molded of plastic tooling compounds developed by Rezolin, Inc., and based on Bakelite epoxy resins and hardeners, and is reproduced in steel by a Keller duplicator. The die face model is cast from a positive model of the finished product, a refrigerator drawer, reducing the amount of hand tooling, time and skilled labor required to produce such a die by conventional means of carving out of steel.

Dr. Harold Mohrman, director of research of Monsanto Chemical Company

Dr. Robert J. Schatz, assistant director of research of Monsanto Chemical Co.



Front fender welding fixture made of dimensionally stable epoxy compounds. This lightweight tool helps produce automotive body parts more accurately, quickly and at less cost than with metal. The plastic tooling compounds are developed by Ren-ite Plastics, Inc., Lansing, Mich., based on Bakelite epoxy resins.



American Cyanamid Company's MELMAC Resin 405 and glass fiber cloth lamination for insulation of many of the current-carrying parts from the base of the Toastmaster, product of McGraw Electric Company. In some cases, these melamine-glass parts replace laminated mica insulators. MELMAC has inherent low leakage to ground, and is able to withstand the high temperatures and humidity encountered within a toaster case.

As pointed out by Dr. Harold Mohrman, director of research of Monsanto Chemical Co. and his assistant, Dr. Robert J. Schatz, the plastics industry of necessity is striving to develop synthetic materials that can be used in place of metals. It is expected that supply sources of some metal ores will approach scarcity in the near future. Highest grade iron ores in the Mesabi range have already become scarce. High grade copper ores are becoming limited.

Summarizing the information given by Drs. Mohrman and Schatz, present researches indicate that it will be possible to produce new moldable plastics possessing good electrical and good heat conductivity and controllable by changes in proportions of ingredients. Electroplating on plastics can now be done easily and economically.

Future progress in plastics will come mostly not from the development of new types of plastics, but by recombining polymers presently available. By new molding methods, great progress will be made in the production of composite moldings. For example, the molded part may be made so that one section is highly conductive while another section is an excellent electrical resistor. A single molded piece might incorporate several electric circuits insulated from each other and molded in one operation.

Monsanto researchers predict thermosetting plastics able to withstand high temperatures for short periods. This might be done by a material that will quickly get rid of the gases given off when the material is heated, these gases being the main cause of the decomposition of material at high temperature.

Combinations of plastics and ceramics or plastics and cermels are in prospect.

Today, asbestos in England and glass fiber in America are the principal reinforcements used in high strength heat resistant plastics. In fifteen years cheaper materials might be found for reinforcing plastics, to open tremendous new markets. It will be in the direction of making the plastic automobile body an economical possibility. Plastic panels, architectural trim and structural members are now in limited use, awaiting a low price strong reinforced plastic.

Dr. Schatz summarized the present situation in baking enamels as follows: "Baking enamels contain a number of polymers. Alkyd makes the film, melamine gives a good gloss finish and helps keep the color bright, epon makes the enamel adhere more firmly. At Monsanto, for every chemist making a new polymer three may be doing applications research such as mixing and testing."

What of the future? Larger moldings, new combinations, new fabricating techniques, better paints and finishes, prefabricated plastic houses, and many uses not dreamed of today.

Fibrous rubber research carried on at Arthur D. Little under the direction of Dr. Laurence R. Hervey for the American Viscose Corporation led to a material that may be suitable for products ranging from girdles, inner soles and rug cushions to conveyor belts and vibration absorption devices. This new form of natural rubber has more strength and less weight than sponge rubber, is porous, has good tear resistance and competes in price with sponge rubber.

Rubber and plastic materials are used extensively in the telephone industry. A molded mixture of rubber and iron oxide is used for magnetic recording. Special formulations of polyethylene have been developed for cable sheaths. Bearings, cams, pawls and gears, easily mass produced require no lubricant, are light and wear resistant.

What might well prove to be one of the most significant advancements in materials treatments is irradiation. A development of the General Electric Laboratories, the bombardment of polyethylene by electrons from a million-volt resonant-transformer type cathode-ray machine creates new properties. The polyethylene becomes a "vulcanized" insoluble infusible plastic having greatly increased resistance to stress corrosion and possessing higher strength at high temperatures. Boiling water has no appreciable effect on the material.

Irradiation also imparts to the material increased resistance to stress corrosion. Practically all the mechanical properties of low molecular-weight polyethylene are improved by irradiation.

Will irradiation prove to be a milestone on the road to making materials more usable at higher temperatures? There is a growing need for plastic and electric insulation materials that will not deteriorate at temperatures of the order of 200 or 300 F. Indeed, the whole program of miniaturization might well be hindered severely by the lack of such materials.

Miniaturization is one of the most sweeping trends of the day. Not only are hearing aids and pocket radios being made extremely small, but the same trend applies with equal force to

Automobile license plates with letters and numerals of Tenite butyrate plastic are now in popular use in the British Commonwealth. Chip-proof and non-corrodible, the butyrate digits remain bright and lustrous throughout long use. The tough plastic material is molded separately and attached with metal fasteners to steel backing plates. Tenite is marketed by Eastman Chemical Products, Inc.

(Right) Here a specialist at Bell Laboratories checks on whether various cords can return to their original shape after long periods of stretching. Under study at the Laboratories is the problem of perfecting a retractile cord in colors.

telephone sets, all kinds of instrumentation and controls and even to electric motors. With more and more features and qualities being incorporated into all kinds of products, the question of size becomes more important.

Except purely mechanical devices, all other types of instruments and controls involve the transmission and transformation or both of electrical energy. There are always power losses, which appear as heat. If the rate of heat generation is greater than the rate of cooling, the temperature of the device will rise until the increasing rate of heat dissipation balances the heat generated. The smaller cooling area compels a higher temperature so that the rate of heat dissipation will be the same as before miniaturization.

Because miniaturization results in higher temperatures, the materials of the miniatured product must be able to withstand these higher temperatures.

In addition to the effects of irradiation on polyethylene, it has also been found that irradiation improves the properties of silicones at higher temperatures. If and when all the secrets of irradiation are uncovered, it might be the start of a whole vast new technology comparable to the heat-treatment of steel alloys. The process of irradiation may extend to the field of metals.

As pointed out by E. R. Bridgwater and V. A. Cosler of Du Pont, rising labor costs work to the advantage of higher-cost materials, because the high-cost material so often saves labor.

Low temperature insulation gives us a good example of cost reduction through use of a higher-cost – but labor-saving – material. Suppose you want to insulate a big valve or other irregularly shaped equipment carrying some cold liquid. If you used slabs of conventional solid insulation you'd have a lot of laborious cutting and fitting to do. There is a new material being developed that has done jobs like this a lot cheaper, even though its cost per cubic foot is two or three times that of conventional low-temperature insulation. The new insulation is called polyurethane foam. These foams are formed by mixing two liquids and pouring the liquid mixture into a mold. The mixture foams, fills the mold and solidifies. By proper selection of chemicals the final foam may be made light or dense, rigid or elastic. To insulate the valve you'd want a very light rigid foam. Little labor is required. You would fabricate an inexpensive cardboard form, hold it around the valve and pour in the liquid. After it foamed and solidified it would support its own weight. Contrast that with the job of cutting and fitting slabs of convenional insulation to cover an intricate shape.

Du Pont has tried polyurethane foam insulation in several of their plants. In a great many cases the economics look very good indeed.

If you want to tease your imagination, think of the labor saving that might be possible by using foams like polyurethane in double walled structures such as refrigerators and freezers. Pour the liquid between the inner and outer walls and let it foam and fill the cavity. It bonds firmly to both walls and you've got your insulation and rigidity all at one swoop.

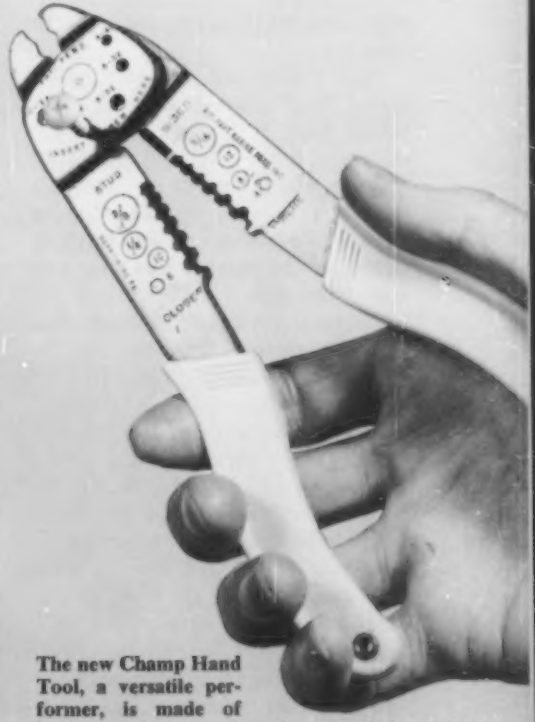
A discussed method of making the automobile seat out of polyurethane is to form the seat in a mold, remove it, coat with an adhesive and apply the fabric. The next development would form the cushion in a mold and apply the fabric facing in the same operation.

Because polyurethane, after being injected as a viscous liquid into a cavity, foams and fills the cavity and converts, without heat, into a rigid foamy material, it has many possibilities for low-cost application. The same applies to any material that possesses the same foaming and forming properties.

In double-walled constructions such as refrigerators and homes, foamable plastics can be used for heat insulation. Very cheap to apply! They can also

(Below, left) Industry bombards plastic film with electrons to achieve form stability. Left to right, Elliott J. Lawton, radiation expert, and Dr. C. Guy Suits, vice president and director of research for General Electric, examine strips of polyethylene. The strip held by Lawton has not been treated, snaps easily, will not retain its strength at temperatures near the boiling point of water. The strip held by Dr. Suits has been irradiated by electrons from a million-volt, resonant, transformer-type cathode-ray machine, to form a "vulcanized" insoluble and infusible plastic.

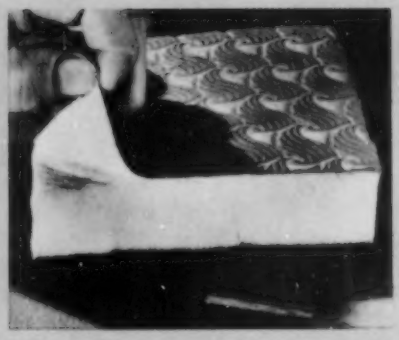
(Below, right) In a specially equipped plastics shop at Murray Hill, this Bell Laboratories chemist is pulling a newly formed plastic part from the kind of mold used in final manufacture of telephone set dial plates.



The new Champ Hand Tool, a versatile performer, is made of heat treated steel and equipped with insulating handles of tough yellow Tenite butyrate plastic.

Birth of Nylon Re-enacted. Probably the most dramatic moment in Du Pont research history was the birth of the first completely synthetic fiber, forerunner of nylon. Here Chemist Julian Hill shows how he pulled molten sample of material from a laboratory tube. The molasses like mass stuck to the glass stirring rod and was drawn out into a thin fiber.

(Left) A tough drop-hammer die made of epoxy plastic compounds stamps shallow trays out of hard aluminum sheet. The die-making compounds, developed by Ren-ite Plastics, Inc. and based on Bakelite epoxy resins and hardeners, withstand repeated impact and shock of forming sheets of aluminum, annealed steel and stainless steel on conventional metal presses.



Soft, flexible foam that breathes can be produced and molded continuously as a cushion backing for textiles and other materials by a method employing plastisols based on Bakelite vinyl resins. The Elastomer Chemical Corp., Newark, N.J., produces a cured foam that is fabricated at a price comparable to foam rubber. The foam breathes because of the interconnecting cells uniformly distributed in molded tubes, blocks or rolls eight inches or more in thickness. The foam plastisol based on Bakelite vinyl resins only scorches under a flame and is self extinguishing when the flame is removed. Controlled variation alters properties over a range comparable to all but the lightest foam rubber to the hardest flexible sponge rubber. The mold can be cast and cured in the lightest of molds, such as, cardboard, as shown above.

serve in sound insulation and vibration damping.

Clad metals are old stuff. Now comes "clad" plastics. An example is rubber clad with colored-as-desired chloro-sulphated-polyethylene, called hypalon, which is ozone resistant. It is made by Du Pont for rubber mounting on auto windshields and rear windows to obviate the stainless trim strip conventionally used.

Foamable "Alathon," a tough flexible polyethylene produced by Du Pont, has high dielectric strength and, about 1/2 air by volume, is exceptionally light. One of its uses is for wire covering. By extrusion, wire coated with polyethylene 10 mm. thick is being produced commercially. Tetrafluoroethylene pipe, relatively new on the market, is used for jet engine fuel lines.

Isofoam, made by Du Pont, was developed specifically for heat insulation. Its base material is mixed with a liquid catalyst and poured into the mold cavity where it forms and sets.

Foamable plastics that set without heat will be one of the big developments of the plastics industry.

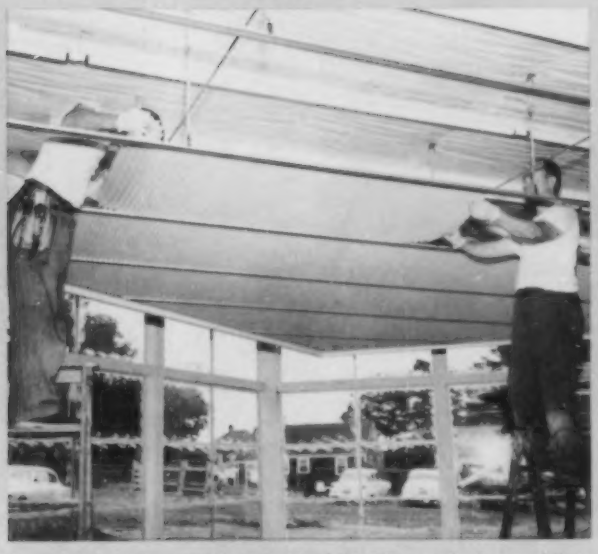
Dow Chemical Company, another leader in the plastics field, also is doing considerable work on foaming plastics. They have recently developed a sandwich construction consisting of foamed polystyrene blocks faced with an inch thick concrete surface on opposite sides. This new development in the building field suggests comparable developments in other fields.

It is significant that there is steady progress in process controls in the chemical industry. This means greater uniformity of product, lower cost production and hence further rapid expansion of the plastics industry. Dr. Turner Alfrey of Dow reports development of complete new sets of instruments for flow control, viscosity measurement, spectrometers, temperature and pressure controls, and other instrumentation. The new Durez Plastics & Chemicals plant at Kenton, Ohio, for making phenol formaldehyde makes exceptionally extensive use of automatic controls and operations.

FILMS AND FABRICS

IN THE PAST DECADES many synthetic fibers were developed, including Du Pont's Dacron, Nylon, Orlon, and Teflon. With these as a base, an endless number of combinations of fabric constructions will be developed. Du Pont's Dr. Lawton Burrows points out that any of these fibers combined with polyester resins will result in a material possessing superior properties.

Du Pont researchers report the development of a large variety of plastic felts, including felted Dacron, Nylon and Orlon, which can be produced to any desired degree of compactness. Unlike wool felts, they do not shrink. These synthetic felts do not deteriorate up to 300 F, as compared to 180 F for



Corrugated strips of Monsanto's rigid Ultron vinyl, pre-cut to exact size and angle and easily unrolled onto aluminum tracks, are installed for a luminous ceiling at a West Newton, Mass., elementary school. One person unrolls material as another gently pulls along track.

BSPI 6671 (Barge, Self-Propelled, Inland) composed almost entirely of reinforced Celanese polyester resin. Used by the Army Transportation Corps, this new 51 foot plastic craft is a light, shallow draft vessel capable of transporting cargo over shallow and restricted waterways. The barge has a speed of 14 mph unloaded and without tow; designed with tow, 7.5 mph. Powered by two General Motors 165 horsepower diesel engines, the vessel can push a fleet of non-powered barges carrying a cargo of 100 tons.

wool, and they show good oil resistance, two factors to give the felts wide use for bearing seals and filter cloths. For the latter purpose plastic felts have the advantage of controlled porosity.

Perfect bonding between glass fibers and the polyester resin produces a material of greater strength and translucency. Perfect bonding means absence of minute air bubbles on the surface of the glass. The bubbles impair light transmission and decrease the strength of the bond between the glass and the resin. Chemicals have been developed with which to coat the glass to obtain bubble-free bond between glass and resin.

Latest of Du Pont's synthetic materials is Mylar. Chemically, it is basically the same as Dacron fiber. Mylar has high dielectric strength, is chemically resistant and remains tough even at low temperatures. It is stable to approximately 300 deg Fahrenheit. It is reported that General Electric Company is using Mylar for slot insulation in fractional horsepower motors.

Most versatile of all plastic materials is Teflon polytetrafluoroethylene. It is extremely slippery, resistant to almost all known reagents, capable of withstanding temperatures up to 500 F, does not become brittle at low temperatures, has practically no cold flow, no water absorption, and excellent electrical insulation. The material can be put into "liquid" form for coatings, made as molded parts, fibers, sheets, and in virtually endless combinations with other materials.

An unusual method of insulating electric wire is first to apply a thin coat of Teflon, wrap with glass and heat. The heat expands the Teflon and thereby compels the glass fibers to imbed into the Teflon. The result is a highly abrasion-resistant wire insulation.

Among other applications, Teflon is used for packings, coating surfaces, plastic finishes and conveyor belts.

A new Ultron vinyl film recently announced by Monsanto is flexible after long periods of immersion in oil or water. It is highly resistant to attack. One application is for protective equipment coverings.

(Far left) Mr. Harold B. Freeman, Technical Director of the Plastics and Resins Division, American Cyanamid Company

(Center) Dr. J. F. Eversole, Vice President of Bakelite Company, in charge of research

(Left) Dr. Ralph Ball, Technical Director of Plastics, Celanese Corporation of America.

Con-Tact, a plastic fabric, manufactured by the Cohn-Hall-Marx Company, New York City, composed of vinyl plastic fibre produced by Monsanto Chemical Company. The fabric is self-adhesive, can be cut easily and is available in a variety of color and pattern combinations.

A 3,400 gallon reinforced plastic transport tank for commercial trucking, to haul formaldehyde and similar liquid chemicals. The tank, one of the largest one-piece molded structures ever made, is constructed of American Cyanamid's Company's LAMINAC Polyester Resin and fibrous glass reinforcement. It weighs only 7,025 pounds, 3,600 pounds less than the steel tank it replaces. Unlike a steel tank, no special lining is required. It is highly resistant to corrosion and requires less maintenance.

PLASTIC COMBINATIONS

ANOTHER MONSANTO PRODUCT is Resinox 3001, an easily molded, high mechanical strength, mica-filled phenolic molding material particularly suitable for radio tube sockets, bases, electrical connectors and terminal strips.

Monsanto has also developed styrenes having unusually good flow characteristics and suitable for thick-section pieces because of the relatively low temperatures and pressures this material requires.

Injection molded protectors for pipe threads made of a Monsanto vinyl resin with built-in rust inhibitor is another example of what can be done in incorporating special properties in plastic formulations.

Plastics is still in swaddling clothes when measured by the yardstick of science and engineering. Published properties of the various materials are frequently incomplete, inconsistent and often misleading. This is not because of any desire on the part of plastics manufacturers to mislead. To the contrary, they know better than any one else the penalty of leading the design engineer into a misapplication. One such "black eye" may take years to heal.

Confusion in the interpretation of the properties of plastics arises from the fact that no yardsticks are available. As Lord Kelvin put it, "Not until we can express it (properties) in numbers, are we on the threshold of knowledge." To designate a property as "good", "fair" or "poor" is like saying a person is "old", "young" or "middle-aged". It all depends on who is talking and who is the audience.

Various standards organizations including the American Society for Testing Materials and the International Standards Organization, are working hard to establish specific, definite, usable standards to express property values of plastics. They have just scratched the surface. Many of the most important properties of plastics, including wetting action, permeability, diffusion, fluid flow characteristics, cannot as yet be expressed in numbers.

On the other hand, researchers on the uses of plastics are on the increase. During the past year R. K. Mueller, Monsanto vice president, announced a grant to Massachusetts Institute of Technology, made for the purpose of increasing the fund of knowledge on the use of plastics in home design. This covers not only plastics as a material for housing design but also for cabinets, mechanical equipment, furnishings and decorations. Out of the project is expected to come new ideas and design data on the use of plastics.

Besides MIT, many university laboratories are conducting researches in plastics, these including Case School of Applied Science, Armour Institute, Cal Tech, Ohio State, Princeton and many others.

ADHESION

MOST DISCUSSION of adhesion has attributed the basic phenomenon entirely to short range atomic forces and dipole interactions. From shop practice and such concepts, there has developed a number of empirical relations used by the engineer who deals with practical adhesives. It has not been possible to establish a set of rules such as are used by the construction engineer or the petroleum chemist, which permit prediction of the behavior of a new adhesive. The development of an adhesive for new uses is largely a cut-and-try process guided by certain general principles.

Recently a new approach to the problem of adhesion has been made by Dr. Selby M. Skinner, Associate Professor of Chemistry at the Case Institute of Technology, in which the contribution of electrical charge transfer between adhesive and adherend is recognized. Experimental curves demonstrated such charge transfer, which is of the same nature as the contact voltage between metals, and, though not exactly the same, is related to the

Plastics have applications in production as well as design. Shown here is one of the Simonds Abrasive Company's high speed snagging wheels grinding out the surface imperfections in steel slab.

Adhesion and cohesion research on polymers, as being carried out at the laboratories of the Case Institute of Technology, Cleveland, Ohio.

charge received by a comb upon rubbing it over wool. A theoretical analysis utilizing statistical mechanical and quantum mechanical concepts confirms that the charge will be transferred. This was not predicted by the older theories. The electrical portion of the total adhesive force is then the attraction between the oppositely charged adhesive and metal adherend. These charges behave like a surface film of negative surface tension, and therefore produce an attraction which can be computed by classical electrical formulas.

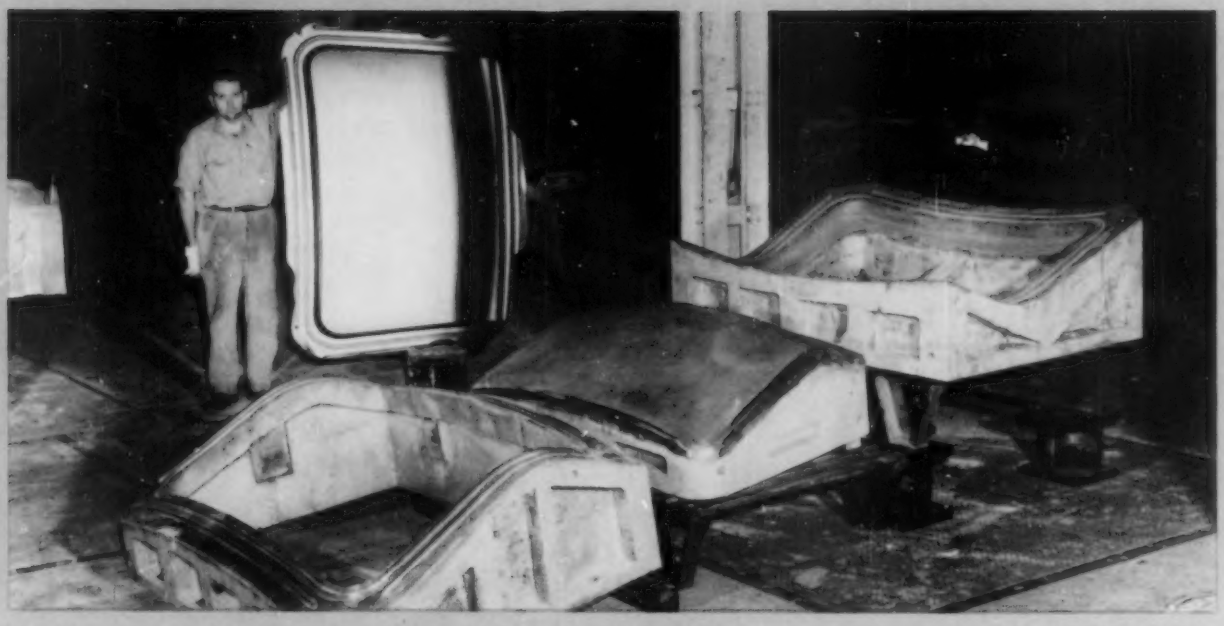
The theory and the early confirming experiments agree with other known behavior of the materials. They show why it is not possible to predict the strength of an adhesive joint from a knowledge of the properties of either or both the adhesive and adherend alone. The adhesion depends upon the relation between adhesive and adherend. They agree with experience in showing that a wide range of behavior will be encountered depending upon the electrical properties of the materials. While the theory has not yet received complete confirmation, further experiments are continuing. The new concepts may aid in eliminating some of the uncertain factors that have made adhesion practice empirical, and thereby decreasing somewhat the overall problem faced by the analyst in establishing rules for practical shop use.

Perhaps the greatest cost element in the production of a machine or structure is the assembly. Riveting, bolting, and the other usually employed mechanical methods all require special preparation. Welding offers many cost reduction possibilities, but all materials cannot be welded. Also, many assemblies must be such that they can be disassembled. Finally, some materials cannot be punched or drilled economically, or it may be undesirable to use mechanical fasteners. Bonding with adhesives, permanent or otherwise, may be the answer.

Brake linings and shoes were formerly attached to the brake band by rivets. This was unsatisfactory. Wear eventually exposed the rivets allowing them to rub on and score the brake drum. Some years ago the Chrysler "cycle welding" process was introduced. This was an adhesive set by heat. It was successful and focused attention on the possibility of developing adhesives for bonding any two engineering materials regardless of composition. An adhesive bond minimizes galvanic action between dissimilar metals as it provides an insulating layer separating the two metals.

Today adhesives are used for an endless variety of bonded assemblies. Many of the adhesives have a rubber base. Research is now directed to developing more types of elastic adhesives of greater shock load capacity.

ONE-SECOND COMMERCIALS: Styrene production by Monsanto in 1955 is scheduled to be 30,000,000 lb. more than in '54 . . . Fiberglas with a perfectly bonded overlay of Du Pont Dacron has a beautiful surface, no water absorption, unusual electrical properties . . . Western Felt has started limited production of Dacron felts . . . Monsanto will spend $9 million for new plastic production facilities including a 1¼ million dollar research lab at Springfield . . . New $4-million plant of Durez Plastics & Chemicals, Inc. at Kenton, Ohio for manufacture of phenol formaldehyde resins will start production this spring . . . Eastman Kodak's new polyethylene plant in Longview, Texas, in production since November, represents part of the company's $300 million plant expansion program begun shortly after World War II . . . Durez Plastics & Chemicals, Inc. plans to erect a plant at Kittanning, Pa., for the production of raw materials for the manufacture of phenol molding compounds . . . American passenger automobiles average 20 pounds of plastic materials per car . . . Leading edges of jet plane wings are made of reinforced plastics which have minimum rate of wear and least friction at sonic and supersonic speeds.



A plastic-faced draw die produced at the Hillsdale, Mich., plant No. 4 of Allied Products Corporation. The face of the die cavity and punch, approximately three eighths of an inch thick, forms tough steel under high pressure, to produce automobile luggage compartment doors. Plastic die compounds developed by Rezolin, Inc., Los Angeles, Calif., and based on Bakelite epoxy resins, are cast to close tolerances and require little finishing. Savings of about 24 percent in production cost and 40 per cent in delivery time have resulted from the use of plastic face draw dies for stamping automotive parts from sheet metal, according to a manufacturer. The high bonding strength of the epoxy resins enables the face to adhere strongly to the zinc alloy base.

Organic adhesives will be of the tailor-made variety, designed for the job with particular emphasis on end use. For example, tailored temperatures for room, working and disassembly. A possible application would be in automobile engines where adhesives could be used as "lock washers." Placed under the head of a bolt, the adhesive would be cured after the bolt was tightened and would withstand engine temperatures during service. In the event of disassembly, bolt and adhesive would be heated to a point just above the operating temperature range where the adhesive would soften, thereby permitting removal of the bolt. This whole cycle could be repeated.

Besides striving for ease of application and rapid cure, researchers will be trying to increase the upper limit of their temperature stability. A temperature of 800 F appears on the horizon. In assemblies, some spotwelds may be replaced by adhesive "tack" welds. Advantages are reduced corrosion at weld points and better impact resistance.

A comparison between epoxy and phenolic adhesives is interesting. For the epoxy at room temperature, bond strength is 9,000 psi and practically nil at 500 F; for the phenolic, its room temperature strength is 3,000 psi, while at 500 F, it is 1,000 psi.

Recent developments by adhesive research chemists at Minnesota Mining and Mfg. Company now make it possible to bond impervious materials to form joints with strengths equal to joints made with mechanical fasteners. Bonded joints offer numerous advantages, such as exceptional fatigue resistance, distribution of stress and self-joint sealing.

High-strength adhesives allow design engineers to specify much thinner materials (metals, plastics, etc.) as no allowance is required for stress concentrations and fatigue around rivet, screw or bolt holes. This fact is of particular interest where weight reduction is an important design problem.

Acceptance of structural bonding has been rather slow because of lack of past use, engineering design criteria, and a method for non-destructive testing of bond quality. It is expected that eventually high strength adhesives will replace riveting and other permanent fastening methods where joint fatigue, joint sealing, and overall weight are major considerations.

FINISHES

A NEW CHEMICAL-FROM-OIL, called C-Oil, has been developed by Standard Oil Development Company.

It is a heavy bodied, sticky, almost colorless liquid based on butadiene—a petroleum derived hydrocarbon also used for synthetic rubber. No vegetable oil is used.

As explained by A. D. Green, deputy coordinator of chemical research, Standard Oil Development Co., C-Oil may basically alter industrial paint formulation. If further developments prove as successful as indicated, paint manufacturers' dependence on linseed, soya, tung and other agricultural oils could be reduced or even eliminated.

Experiments show that surface coatings made from C-Oil are so hard it is difficult to scratch through them. Submersion in a harsh chemical solvent has no effect upon the coating. Similarly the coating has demonstrated excellent resistance to attack by alkali, dilute acid and to water.

It has also been used with experimental enamels and varnishes and produces a lasting mirror-like gloss. The finish is so smooth and hard that a

Research in the field of organic chemical coatings is being carried out at the Mellon Institute, Pittsburgh, Penna. In the laboratory view pictured radioactive tracers are being used as a tool in coatings investigation.

Microscopic examination of metal to metal test bonds gives the research engineer some of the data necessary to determine proper adhesive film thicknesses, heat and pressures.

damp cloth will remove any stain or smudge.

Glass-like plastics which may be machined almost like metal have been made from the new product, and unusual electrical properties indicate a future use for C-Oil plastics in high frequency electronic equipment.

Nonbrittle ceramic coatings produced by a "solution ceramic process," as it is called, has been developed by Armour Research Foundation. It is an adherent, inorganic coating obtained by spraying the "solution ceramic" on the heated surface. The new coatings are not brittle. They can be applied to almost any clean, solid surface at a temperature of a few hundred degrees Fahrenheit. Unlike other sprayed ceramic coatings, solution ceramics do not contain any bonding agent.

Among the many solution ceramic coatings available, those studied thus far include refractory metal oxides—zirconia, chromia, titania, ceria and the like. Certain phosphates, silicates, fluosilicates, oxyhalides and even metals can be deposited and two or more different materials co-deposited or applied in separate layers.

The solution ceramic coatings can be used as base coatings for materials that could not otherwise be applied to a metallic surface. For example, silicone will not normally stick to steel. However, mild steel specimens have been coated with zirconia and then finished with a silicone. The porous surface of zirconia gives good adhesion to the silicone. It is notable that zirconia, melting point of which is nearly 5,000 F, can be applied to material heated to less than 500 F.

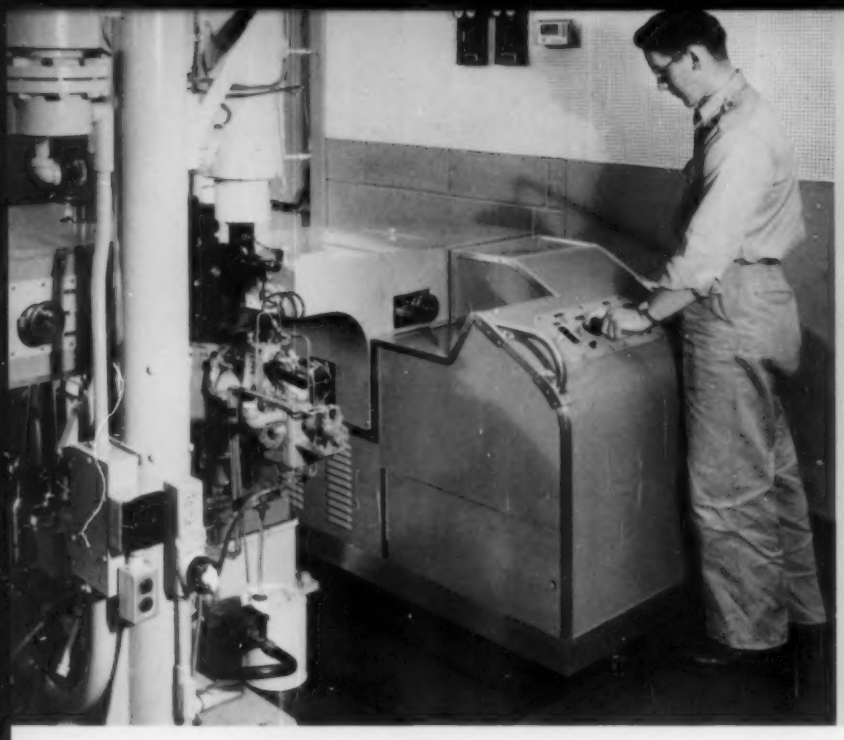
Since solution ceramics are deposited from true solutions, the rate at which they are applied can be accurately controlled by varying the concentration of the solution. Coatings of infinitesimal thicknesses can be deposited by using dilute solutions. Thicknesses of a few millionths of an inch have been used to coat magnetic laminates without significantly increasing their packing factor. Normal thicknesses are between 2 and 5 thousandths inch. On a laboratory basis, 0.010 in. is the thickest coating that has been applied.

Tests on flexible tube fittings with ceramic coatings on the inside surface indicate that some forming can be done after the coating has been applied. Fatigue tests on these fittings show that the metal always failed first.

Solution ceramic coatings are protective against corrosion, mechanical erosion and high temperature. To withstand the attack of ordinary vapor or liquid phases, overlay coatings are generally necessary.

At Battelle Memorial Institute, researchers on electroplating are investigating the possibilities in using alloys for electroplating anodes. Preliminary results indicate that the alloy anodes give a plating that has superior protection characteristics. This same project is giving special attention to automatic plating possibilities.

As reported by Malvern J. Hiler, president of The Commonwealth Engineering Company of Ohio, that company developed a new line of resins made from dextran or glucose polymers. These resins can be used for molding but are specially suited for cellulose nitrate or acetate lacquers. These dextran resins, able to withstand temperatures of the order of 600 to 700 deg F, are being produced by Midland Chemicals Company of Dayton, Ohio.



Left – The engine spectrometer. The spectrometer light source is on the left, the receiver unit, housing the optical system, light detectors, electronic amplifiers and data recorder, on the right. A Du Pont technician at the Petroleum Laboratory, Deepwater Point, N. J., is shown adjusting the sensitive electronic amplifier controls. Between the light and source units is a single cylinder engine. The spectrometer will test the effects of additives on the burning of fuel in the engine combustion chamber. A beam of light passing through the windowed combustion chamber is broken up into its many colors and frequencies and impinges on a photosensitive cell, whose output is recorded electronically on a strip chart.

Right – Dynamometer Laboratory at Standard Oil Company of Indiana. Sixteen engine test stands with dynamometer and other up to the minute control and measuring instruments are mounted on separate 3-ton concrete foundations to eliminate cross vibration in Standard's new dynamometer laboratory at Whiting, Ind. Here new and improved motor gasolines and lubricating oils are engine tested under a wide range of operating conditions.

More Power and Efficiency in

IT IS SAID that Jules Verne predicted that aircraft would not be successful until it was possible to deliver one horsepower out of an engine no bigger and no heavier than a watch. Considering the weight and size of watches in Jules Verne's day, man has about reached that goal. A modern radial gas engine weighs less than one pound per horsepower delivered. Maximum engine horsepowers over the years since 1930 have about doubled every decade. In 1930 a 700 horsepower engine was considered tops. By 1940 this figure had jumped to 1,700. But pressure of war developed the 18 cylinder radial aircraft engine which delivered more than 2,200 horsepower and today the figure stands at approximately 3,700.

Progress in the efficiency and output of the automobile engine has followed the same trend. Today the 125 horsepower passenger car automobile engine is common.

In the operation of any internal combustion engine three principle factors are involved. These are the fuel, the lubricant and the mechanical design of the engine. The amazing progress that has been made in the automobile and aircraft engine has been the result of intensive researches in fuels, fuel additives, lubricants and engine design.

According to the long established Carnot Cycle Efficiency equation, the highest possible efficiency that can be attained by any heat engine is determined by the temperature of combustion and the temperature of the expanded exhaust gas leaving the cylinder. Therefore, the higher the combustion temperature the greater will be the efficiency, the less will be the fuel consumption and the more will be the ton-miles per gallon.

Unfortunately, many complications are encountered when the compression pressure is increased in order to obtain a higher temperature of combustion in the cylinder. For a given fuel and conditions of combustion there is a definite limit to the compression ratio. Beyond this limit the familiar harmful knock develops. It is this factor which has paced the rate of development of the automobile and aircraft engines.

Increased compression ratios had to wait upon a fuel that would burn satisfactorily in the combustion chamber without preignition or knocking. Because deposits in the combustion chamber greatly affect the burning of the fuel, it was necessary to make researches on both fuels and lubricants looking toward the minimizing of deposits on the walls of the combustion chamber. Practically all of the major oil companies have participated in this research program. And because the solution of the problem was of a chemical nature and might well be found through the development of fuel additives, the chemical companies were intensely interested.

As explained by Daniel L. Pastell of E. I. du Pont de Nemours & Company, the reactions of the fuel and air mixture that resulted in the harmful knock have never been understood or thoroughly investigated because of the extreme complexity of the reactions that take place in the combustion chamber at an extremely high velocity. Elaborate and costly experimental techniques would be required for such studies.

Recently at the Du Pont Petroleum Laboratory there was installed a unique engine spectrometer by the use of which the highly important but little understood reactions that take

Smaller Packages

place in a combustion chamber of an automobile are revealed. With this spectrometer Du Pont scientists are taking a new look at the old problem of finding out exactly what goes on in the engine combustion chamber when a gasoline and air mixture is compressed and ignited.

The results of this research work being done at Du Pont with the engine spectrometer are expected to aid in the development of new chemical additives for gasolines that will permit the use of higher compression ratios and thus give the motorist an even greater value for his gasoline dollar.

The engine spectrometer installed in the Du Pont Petroleum Laboratory is built around a single-cylinder engine having a window on each of the opposite sides of the combustion chamber. A beam of light is passed through the chamber from a source unit which generates ultraviolet, visible or infrared light as desired. Some of the light entering the combustion chamber is absorbed by the partially reacted fuel-air mixture.

Any light not absorbed by the reacting gases passes out of the combustion chamber through the exit window and into a complex optical system of prisms and mirrors. This optical system also breaks up the light into its many colors or frequencies. The light impinges upon photoelectric cells in the instrument and is converted into electrical impulses that are automatically recorded on a strip chart.

Since each chemical reaction occurring in the combustion chamber has a characteristic light absorption pattern, the spectrometer can be used to make an analysis of the rapid chemical changes taking place within the chamber. In this way the reactions leading to knock can be followed in the engine and analyzed in detail.

This unique spectrometer, the only one of its kind, was specially developed for the study of engine knock and is another example of the application of basic research in the solution of a problem. Thus are developed the better products at lower costs for the world of tomorrow.

After completion of the basic research comes the development of the superior fuels, lubricants and the design of the engine to use them. Every engine design is most suitable for a certain type of fuel, hence the close collaboration between engine builders and oil companies. That is why the oil companies find it necessary to conduct comphrehensive tests on all the designs of commercial engines as they are developed.

Each new engines must be tested with various fuels and lubricants and put through exhaustive tests that cover all conceivable conditions of operation from the Arctic to the Equator, from sea level to mountain tops. It is not sufficient to merely determine that the new engine runs smoothly. The more important question is: how does it run after one hundred hours of operation? Combustion chamber deposits quickly cause the development of engine knocks and low efficiency.

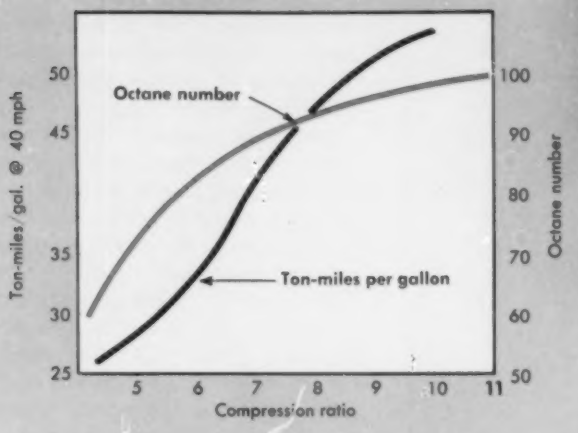
In the accompanying chart is shown the results of the important developments over the past two decades wherein the compression ratios used in commercial engines have increased from 5 or 6 to 1 up to about 9 to 1. Laboratory tests have carried this compression ratio up to 10 to 1 in the investigation of the behavior of fuels of various octane numbers.

The increase in ton-miles per gallon of fuel with increased compression ratio is almost proportional to the increase in compression ratio as shown on this chart.

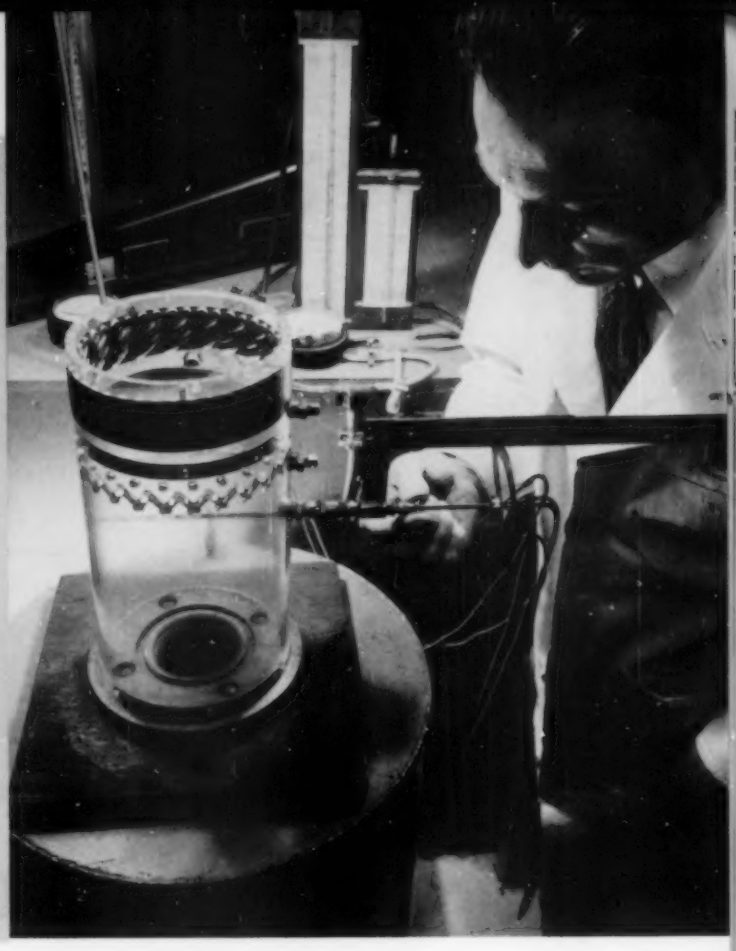
Not all the gain can be attributed to higher octane numbers and resulting permissible increases in compression ratios. Superior lubricants and improved engine design have also played prominent parts. But whatever the factors, the motoring public has gotten a direct benefit from the sixty per cent increase in engine economy that has resulted from the collaboration of both oil chemists and engine designers. To this must be added the gain to all that comes indirectly as a result of the more efficient passenger and freight transportation on the highways.

As was mentioned, lubricants are equally as important as fuel in their effects on the operation of a gas engine. The lubricant affects the behavior of the fuel and vice versa. The deposition of combustion chamber deposits is determined by many factors including the fuel, the lubricant and the design of the engine.

The significance of combustion chamber deposits is indicated by the 5 to 15 increase in octane number that is required to keep an engine running smoothly after the first few thousand miles. Another of the aims of the fuels



Above — High compression ratio engines have higher efficiency and power output but these engines must have high octane gasoline to run smoothly.



Right — Many times in the development of equipment success or failure depends on small details. The reason for the wide acceptance of the diesel engine is its high efficiency, but the efficiency of the engine depends on the efficiency of its parts. The research engineer in this picture is checking the effect of small changes in port angle and location on scavenging efficiency of a diesel cylinder.

and lubricant researches is to develop fuels and lubricants that will minimize engine deposits and thereby keep the engine running smoothly. Distinct progress is being made in that direction.

Indicative of the advances being made in lubricants, G. W. Watts, Director of Engineering, Standard Oil Company of Indiana, reports a new line of automotive engine lubricating oils that are claimed to cut oil consumption by an average of 37 per cent and at the same time minimize the car's need for higher octane gasoline as the car gets older. These savings are explained by not only reduced engine friction and drag but also the reduction in cylinder deposits which result in far better combustion.

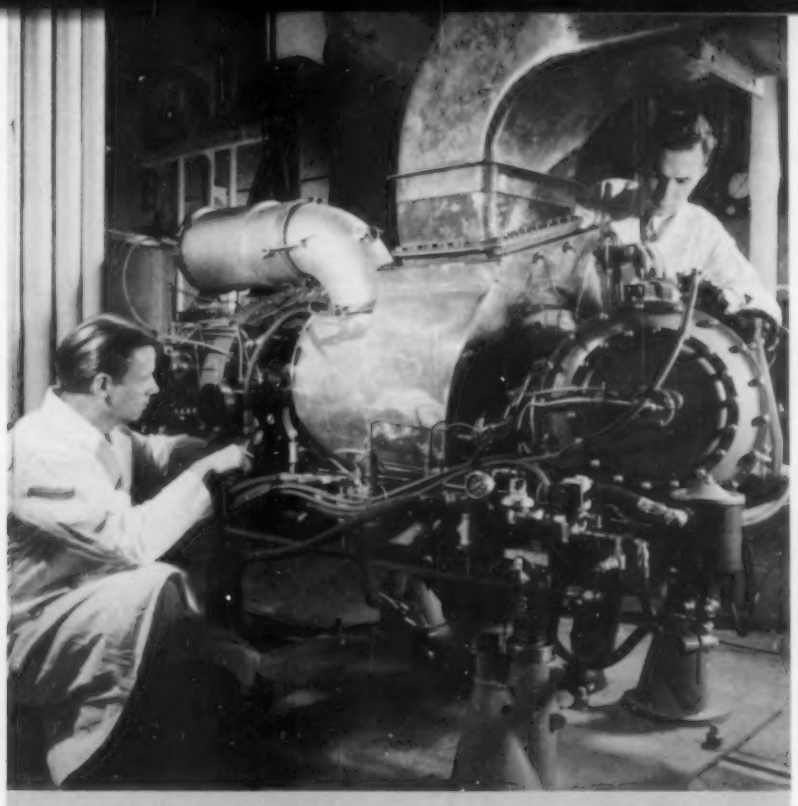
Dr. C. L. Fleming, Jr., Director of the Research Division of the Standard Oil Development Company, points out that the greatest progress in both fuel and lubricating oils come from the chemical laboratories that are developing the additives plus the new processing controls in the manufacture of the gasoline. The additives tend to control the sludge and varnish in the crankcase and helps prevent deposits from forming in the combustion chamber. The new oils, as pointed out by Dr. Fleming, will reduce knock and preignition and thereby improve combustion even with fuel of the same octane number. In view of the fact that the octane ratings of gasolines for automotive use will reach a limit of about 98, it is extremely important that the gains that can be obtained from improved oil be realized. At this point the cost of the fuel will outweigh the value of the improvement it gives in automobile performance.

With further reference to the use of additives, there is still much to be learned. The phosphate compounds, the best known of the present additives, do reduce preignition in high compression engines but they also increase the amount of deposit in the combustion chamber. Boron, which has been tried as a fuel additive, gives only a slight beneficial effect and has a number of disadvantages.

Another interesting development reported by Standard Oil Development Company is in the use of propane gas, especially for city buses and trucks. Many researchers and engineers feel that under proper conditions the use of bottled propane for automotive fuel will spread rapidly. Its use can solve a number of problems.

Buses and trucks can be designed to carry the bottled propane gas in packages similar to the bottled gas for home and industrial use. This gas will permit extremely clean operation of the engine in that there will be no deposits formed in the engine, combustion in the cylinders will be more complete and the engine efficiency about the same. The gas fumes and odors will be negligible and if the merchandising of the bottled gas becomes established on a scale comparable to the sale of gasoline, the overall operational costs of propane gas will be substantially lower than operating with gasoline.

Here is a development that may vastly affect the design of the automobile in the future. The engine operated on propane gas will require no carburetor, and there will have to be a number of modifications in the engine design. Also, the vehicle will have to be provided with special tanks that can be replaced with refills about as conveniently as the present automobile tank can be filled with gasoline.



Being adjusted here for a dynamometer performance test is the GT-300 gas turbine engine, used to power the Turbocruiser, a commercial type General Motors coach. Research on such developments as this one help lead the way to possible automotive power plants of the future.

In the field of engines, we can also look towards great developments in the gas turbine. The major automobile companies are spending much time and money in developing designs. It is not radically new. Boeing Aircraft has had an automobile truck running on a gas turbine for a number of years. There are many problems involved.

The volume of exhaust from a gas turbine is many times greater than the volume from the conventional reciprocating engine. However, the exhaust from the gas turbine is much cleaner.

Efficiencywise, the gas turbine design must still be improved considerably. Too much of the energy is being wasted in the high temperature exhaust. There are several extremely attractive advantages in the gas turbine. It is smoother running. It can burn any kind of fuel including kerosene, benzene, fuel blends and industrial fuel oil. Leaded gases will definitely not be used because they will deposit lead compounds on the turbine blades.

In the field of high horsepowers, several of the railroads are running gas turbine locomotives. A number of large gas turbine units have been put into operation for power generation. Clark Bros., a Division of Dresser Industries, is nearing completion of a 4,500 kw gas turbine driven generator unit mounted on a railroad car for the Bureau of Docks, U. S. Navy. Burns and Roe were the consulting engineers for the Navy. It is the biggest portable power plant yet developed.

The car on which the power plant is mounted was designed and built by Puget Sound Bridge and Dredging Co. and is designed for fast transportation to any disaster area where electrical power must be furnished from an outside source.

In the field of aircraft, the jet engines, ram jets and turbojets are making new records. It must be remembered that these power generating packages are still in their infancy and the next decade will undoubtedly bring about many new developments.

Because of the stringent lubricating requirements in jets and turbojets a number of synthetic oils have been developed. Dr. C. L. Fleming, Jr., of Standard Oil Development Company, reports that these oils are completely synthetic, in that no petroleum products go into their makeup, and that they are good for operation over a wide temperature range and under greatly varied climatic conditions and loads. Bearing life has been substantially improved by the use of these synthetic oils. Because they require much smaller oil coolers they save weight in aircraft installations.

Presently the cost of synthetic lubricating oils ranges from 15 to 20 dollars per gallon. It is extremely doubtful that their cost can be reduced appreciably. However, it is possible that if the automobile engines go to much higher compression ratios it may be desirable to use synthetic oils.

At the Thayer School of Engineering of Dartmouth College, Professor James A. Browning in a research program jointly sponsored by the Office of Naval Research, the Office of Scientific Research and the Office or Ordnance Research is conducting basic research looking toward the solutions of the current "flame-out" problem encountered in jet aircraft. This same work is being conducted by many other institutions in the country.

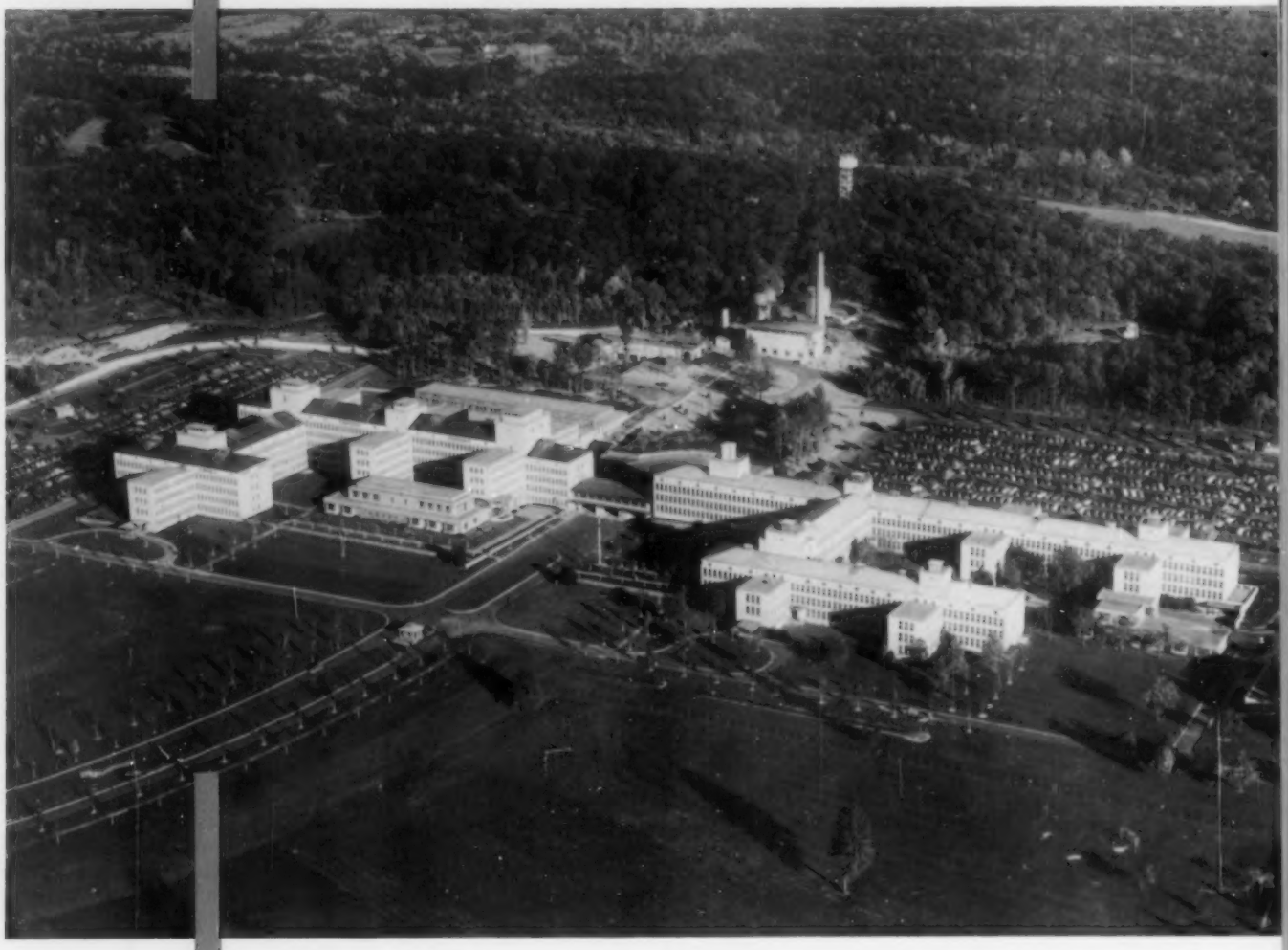
Further researches conducted by Professor Browning relate to the companion problem of combustion efficiency. Many different fuels have been studied for the purpose of achieving improved combustion control that will permit higher flame temperatures and improved combustion control for producing better welding.

At the Ohio State Research Foundation, studies of pure hydrocarbons as engine fuels is one of the major undertakings. Up to date more than 300 synthetic experimental fuels that are practically pure hydrocarbon have been developed. It is of necessity that some of the current hydrocarbon fuels now used commercially for engines contain more than one hundred compounds. This gives some idea as to the amount of impurities in these fuels. There are between 4,500 and 5,000 hydrocarbon types in gasoline, the carbon amounting to 0.2 to 0.3 per cent of the content.

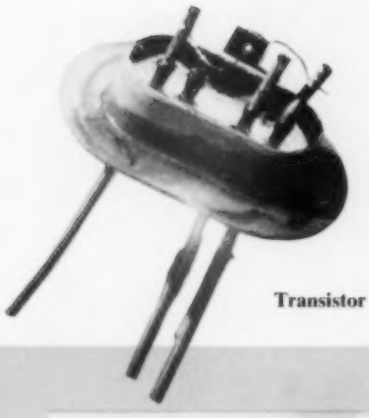
The work being carried out at Ohio State is expected to result in a fund of data and information that will be of great importance to design engineers because of the interrelationship between the fuel and the materials of construction used in the engines. The whole problem is extremely complex not only because of the chemistry involved but also because of economic factors.

The World's Largest

The Murray Hill Facilities of the Bell Telephone Laboratories



In the peaceful New Jersey countryside lies the main facility of Bell Telephone Laboratories, where 1200 engineers and scientists, 700 lab assistants and technicians and 1600 other supporting personnel work. At nearby Whippany another facility engages 1700 mainly in highly classified government projects. Bell Telephone System also maintains laboratories near Red Bank, N. J. and in New York City. The four employ a total of over 9,000 people.



Transistor

Sample of the Many Products of Bell Research Some Serve Outside the Field of Telephony

Miniaturization

Telephone and Television Relay Antenna

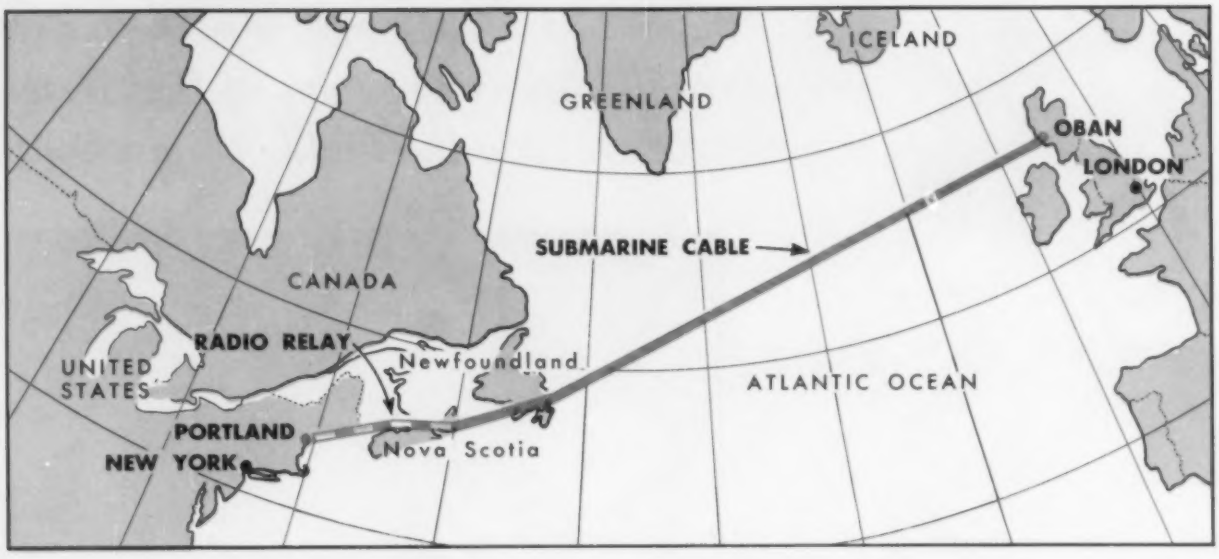
Hearing Aid

Solar Battery

Electronic Eye

Artificial Larynx

Automatic Message Accounting



Another Milestone in Communications

UP TO THE PRESENT TIME telephonic communication between the North American continent and Europe has been via transatlantic radio in conjunction with overland telephone circuits. Now the longest underseas voice cable in the world is being laid on the bed of the Atlantic Ocean from Nova Scotia to Scotland. The cable will be owned jointly by American Telephone and Telegraph Company, the British Post Office and the Canadian Overseas Telecommunication Corporation.

Indicative of the magnitude of the problem and the thoroughness with which it was attacked, developmental and research work on this cable has been in progress for more than 25 years. The project will cost 35 million dollars and will require three years to complete. Innumerable technical and economic problems had to be solved.

The voice currents will travel along coaxial conductors which will be insulated by a solid layer of polyethylene, and protected by a wrapping of copper foil over which will be a heavy cover of jute and steel wires.

In the 2,000 mile stretch of nautical cables lying on the ocean's bottom will be many vacuum tube repeaters, some of them as much as three miles below the surface of the ocean. They had to be designed so that they could be laid successfully from a cable ship and would operate under great pressures, more than 7,000 lb. per sq. in. in some places, existing in the floor of the ocean. There will be more than one hundred underwater repeaters, for which vacuum tubes long have been under development.

It is unofficially reported that the vacuum tubes in this cable are expected to last twenty years. They have been installed with a replacement tube so arranged that if the original tube fails the replacement tube can be thrown into the circuit in place of the failed tube without disturbing the cable.

Each repeater will contain about sixty electrical elements including three vacuum tubes which have withstood both laboratory and underwater operating tests of the most severe kind.

The new cable is a striking example of how a big step in progress is achieved not at a moment's notice but as the culmination of years of painstaking planning, research and engineering design. In it is embodied a vast range of new developments – from a tiny vacuum tube to a huge cable-laying ship.

Technician assembles sections of a submarine cable amplifier for test in the Bell Laboratories. About 60 electrical elements are contained in the tiny amplifier.

Inventors of the Bell solar battery, G. L. Pearson, D. M. Chapin and C. S. Fuller, at Bell Telephone Laboratories, checking sample devices for the amount of electricity derived from sunlight, here simulated by a lamp.

Philco's electro-chemical process for fabricating its surface-barrier transistor, is shown above with Mr. William E. Bradley, Philco research director, at the controls of a jet stand where etching and plating of silicon for transistors is conducted.

Mysteries of Electricity Deepen As Science Uncovers New Behaviors

Each time that scientists come up with a new discovery in the field of electricity, it seems to the lay mind that finally the end has been reached. But each new forward step serves also as a powerful tool to help prod out further secrets and to open the eye to yet broader vistas. The result: more new and even greater possibilities.

TO BELL LABORATORIES SCIENTISTS, Dr. Walter Brattain and Dr. John Bardeen, working under Dr. William Shockley, go the honors of having discovered and built the theory of the transistor and invented it. It is highly significant that this is one of the major scientific discoveries in which all the subsequent inventions and developments were based on scientific understanding rather than experiment.

Transistors serve primarily as rectifiers and voltage amplifiers, and for these purposes can replace, within limitations, vacuum tubes. They also can serve as thermistors. Transistors are small in size, low in power consumption and heating, and have a long life. By virtue of these characteristics, transistors will make automatic control practical and economical where it is now impossible, because vacuum tubes take up too much room, cost too much, are not sufficiently durable and do not have a long enough life.

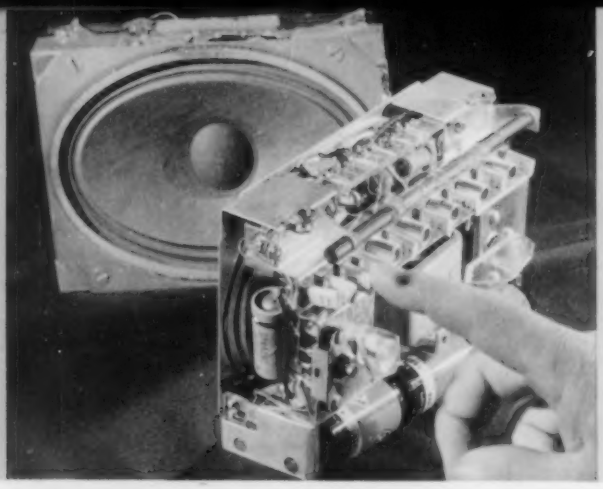
The features of transistors make them extremely valuable to the telephone industry. In telephone systems only minute power is needed for carrying the voice. However, telephone circuits require the use of vacuum tubes which require hot-filament currents of appreciable magnitude. Also telephone circuits require relatively heavy currents for switching purposes. If it were possible to circumvent the use of tubes and hence the hot-filaments, and if it were possible to develop a switching technique that would not require high intensity currents, much would be gained.

Transistors operate on micro currents. No hot-filament is involved. Replacing vacuum tubes with transistors eliminates the relatively high hot-filament current. By the use of transistors and semiconductors, it is also possible to obtain faster switching with lower power. A further advantage is that the life of a transistor is indefinite.

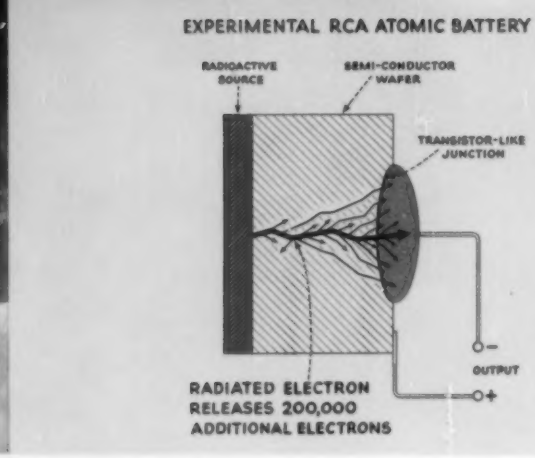
Because voice transmission by electric current requires only micro power, it follows that any simple means for the generation of electricity even in only minute quantities might be of great value. With transistors giving great promise toward the elimination of the need for high power, the development of a simple micro power generator appeared attractive.

Specifications for the micro power generator desired for voice transmission were basically simple. It should have no moving parts that might wear out, nor require lubrication, adjustments or other manual attention. The power source was not to be of a nature that would require frequent replacement, as would dry batteries and storage batteries.

Light sensitive or photoelectric cells were available but their power output was insufficient. However, there was the possibility that the silicon transistor might provide the answer, with



Laboratory model of portable radio receiver which uses new RCA experimental radio-frequency junction transistors. Receiver operates for 500 hours on six small-size flashlight batteries. It was designed by Loy E. Barton, RCA research engineer, at the David Sarnoff Research Center of RCA, Princeton, N. J.



Simplified cross-section view of experimental RCA Atomic Battery. This combination of radioactivity and semiconductor techniques has made possible in the laboratory first direct conversion of atomic energy to usable electricity of sufficient energy to operate a transistor.

the sun as the prime source of energy. That is, a solar battery.

Early in 1954 Bell Telephone Laboratories announced the invention of the silicon solar battery to convert sunshine into electricity.

The solar battery, now capable of delivering 80 watts of electricity per square yard of surface, uses strips of specially-prepared silicon to convert the sun's energy directly and efficiently into electricity. The Bell Laboratories scientists have experimentally used the solar battery to power the transmission of voices over telephone wires and to power a transistor radio transmitter carrying both speech and music. Already achieving more than 8 per cent efficiency in converting sunlight into electricity, Bell Laboratories expects to increase this with improved techniques. Other photoelectric devices have never been rated higher than one per cent.

The transistor, is the heart of a new telephone system which promises to bring more and better telephone service to the nation's rural areas – without adding more telephone lines.

The new system permits many conversations to share a pair of telephone wires without interfering with each other and gives economical operation over distances as short as five miles. Other systems not using the transistor have been able to operate economically only over much longer distances.

The first complete system of telephone equipment to use transistors is now being installed for a trial near Americus, Georgia, about 135 miles south of Atlanta.

More than 300 transistors will be used. Their small size is expected to cut the over-all size of the equipment to about one-tenth of what it would be if vacuum tubes and their related equipment were used. The transistors will require so little electric power that the batteries needed to supply it will be hung on the telephone poles with the transistors.

As an example of the small power requirements of the transistor, the carrier equipment in the trial at Americus will require for each terminal only a twentieth of an ampere or less, at 20 volts, in comparison with a power requirement 20 to 30 times as great, what would be necessary if vacuum tubes were used to perform similar functions. Batteries will therefore be used to supply power to these equipments.

More About Transistors

Since the announcement of the transistor by Bell Laboratories in 1948, interest in semiconducting materials and devices has increased markedly. Researchers are still looking for the answers to some basic questions. For example, in producing a germanium semiconductor or transistor to a purity of one part in 10 billion, it is slightly contaminated (one part in 100 million) with arsenic or antimony. The germanium has certain electrical properties. But if some other metal, such as gold, is used as the impurity, the properties are drastically different. Why?

Electronic engineers currently divide transistors into two families: point-contact transistors, the elder of the two varieties, and junction transistors. Within each family there are a number of types, designed to accentuate certain characteristics, such as high-frequency application or the ability to handle greater power.

Point-contact transistors are built around a miniature block of germanium crystal with two "cat whiskers." Developments indicate that this family has particular advantages over the junction variety as an economical high-speed switch in electronic computers and in many kinds of equipment needing a control device at higher frequencies, such as certain television and FM radio circuits. At first the frequency response of point-contact transistors appeared limited to 4 or 5 million cycles per second; recently RCA has caused one type of point-contact transistor to oscillate as high as 300 million cycles per second. The prospect of extending into higher frequencies, up to the range of UHF television and into the upper realm of microwave frequencies, seems favorable.

The junction transistor is built around a tiny sandwich of two kinds of germanium or silicon crystals, n-type germanium, which has been doped with traces of impurities so that it has an excess of electrons (thus n-type, negative), and p-type germanium or silicon, which has a deficiency of electrons (thus p-type, positive). The sandwich usually has three layers arranged n-p-n or p-n-p, with connecting wires touching each layer. The sandwich can be prepared by introducing the alternate types of impurities as a crystal is grown or it can be made by fusing small blobs of n-type material to both sides of a sliver of p-type germanium crystal (or vice versa). The latter

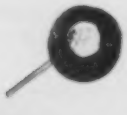
method, now being refined for transistor production by RCA, appears to be more simple and precise.

The junction family, according to circuit experts, will probably be the workhorse amplifiers in radio and television receiver circuits, in phonograph and other sound amplifiers, in pocket radios and any spot in the home or in industry where the boosting of a weak signal is desired.

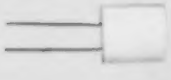
The parts of the Atomic Battery designed by RCA.

STRONTIUM 90
RADIOACTIVE
MATERIAL
(Amount Actually Used)

CONTAINER
(Holds Radioactive Material)



SILICON WAFER
Transistor-Type Junction



COMPLETE ATOMIC BATTERY

When a large energy gap is essential —and where temperatures exceed 75 to 100 C, germanium is no longer a satisfactory material. Work at several laboratories, including Bell Labs, indicates that silicon is the answer—though it is more difficult to purify.

Perhaps more important than work now being done on materials is research into new forms of semiconductors. National Bureau of Standards has just announced a silicon diode (two-element) amplifier that owes its operation to a characteristic of semiductors heretofore considered undesirable—the reverse transient phenomenon. Developed by A. W. Holt, chief of NBS's components and digital techniques section of the data processing division, the new amplifier can have a power gain up to 10 per stage and has operated in a current-doubler type flip-flop circuit.

At Armour Research Foundation, Dr. James J. Brophy and his staff are devoting much of their efforts toward the development of multi-electrode transistors. These, they believe, will give the transistors gain, power capabilities, low noise, high frequency applications and cost comparable to the vacuum tube.

Adding another connection to the base of a conventional junction triode results in a tetrode transistor that improves high frequency characteristics. Such units will have useful gains up to almost 10 megacycles. Base voltage also may be used to control the amplifier gain, providing a simple volume control.

A radically different form of transistor, still in the experimental stage, at Armour Research Foundation, is the field-effect transistor. A battery causes current to flow the length of a semiconducting bar between contacts called the "source" and the "drain." This current is controlled by electric fields set up within the bar by junctions at the "gates." The voltage of the gates varies the channel through which current can flow. Like vacuum tubes, this device has a high input resistance in contrast to the conventional transistor. It also promises to be satisfactory for high frequency operation. Calculations show that 120 megacycles should be achieved with units of practical size. Test models, however, have not fulfilled this promise as yet.

Another multielectrode transistor incorporates an additional junction, which causes current multiplications of as much as 1,000. Although Armour Research Foundation personnel are enthusiastic about the merits of this structure, it is difficult to fabricate and has yet to progress beyond the stage of laboratory demonstrations. Present units are limited to low frequency applications.

Scientists at Bell Labs have modified a conventional junction transistor, which is in essence a sandwich made in a germanium or silicon crystal, with a very thin region of one electrical type separating two adjoining regions of a different electrical type. They have produced, in effect, a "club sandwich" by adding an intrinsically pure layer to this basic positive-negative-positive wafer. This layer acts as a shock absorber for high voltage electrical charges. The intrinsic region within the transistor permits the faster movement of positive charges, isolates the input and output areas, and reduces the stored energy to make possible functioning at frequencies of 440 million cycles. The increased separation of input and output also permits operation of up to 100 volts – voltages higher than are possible with conventional transistors.

Dr. J. M. Early who invented this new transistor, and was assisted in its development by W. C. Hittinger and Dr. J. W. Petersen, forsees its use in portable radios, the transcontinental radio relay system, and submarine telephone and television cable repeaters besides countless other commercial and military applications.

A development termed one of the most important in recent years in the field of polar semiconductors, was recently credited to two Naval Ordnance Laboratory physicists – Wayne W. Scanlon and Robert F. Brebrick. They have a general technique for preparing crystals of polar semiconductors which provides accurate control over the crystal composition and hence of its electrical properties. Control over the electrical properties of semiconductors is of the utmost importance in the manufacture of rectifiers, transistors and infrared detectors. Because of the nature of polar semiconductors, control of the electrical properties by methods currently used so successfully for germanium and silicon is not applicable.

The method developed at the Naval Ordnance Laboratory has been applied to the semiconductor, lead sulfide, which is of importance in infrared detection. However, the method may also offer a new approach to intermetallic semiconductors, which have advantages over germanium and silicon, now being used in transistors and rectifiers. The technique has made possible a comphrehensive study of the basic physics of polar semiconductors.

Before the technique was developed it was impossible to predict the composition of such materials as the sulfides, selenides and tellurides of lead. The fact that certain of the crystals contained various concentrations of electrons or holes would be attributed to an accident of their geological origin or of happenstance in their preparation. This lack of control has hampered and delayed important basic research.

The use of the new technique provides control over the crystal composition to one part in a million. Furthermore, it determines whether the semiconductor shall be "p-type" or "n-type."

As an indication of what transistors can mean to product design and development, the Naval Ordnance Laboratory has developed a transistorized radio transmitter that is small enough to fit in the nose of a 20-millimeter projectile and so durable that it withstands the heaviest shocks to which it is subjected in firing the shell. The plastic nose that houses the transmitter is about one inch long and has an inside diameter of roughly one-half inch.

A germanium semiconductor the size of a dime can rectify 110-volt 60-cycle ac power of sufficient amperage to run a 10-hp motor under laboratory operation. Signs point to the use of these transistors as a part of the drive of every medium horsepower machine where adjustable speed – and therefore a dc driving motor – is desired.

Another promising development in the field of semiconductors is that of the photoconductive cell, which has gained attention through its use in automotive headlamp controllers.

The photoconductive cell is classed as a semiconductor device because its operation depends not upon electronic emission in a vacuum, but on electronic conduction in a solid. The resistance of the cell is a function of the intensity and wave length of radiation falling upon a radiation-sensitive crystal within it. The cell develops its highest resistance when no radiation is directed to it, and a diminishing resistance as the radiation increases. Its sensitivity is comparable to that of the photomultiplier. Of all the materials that exhibit photoconductive properties, cadmium sulfide and cadmium selenide appear best.

When used with a transistor-amplifier, the photoconductive cell works best with the grounded emitter type. In this arrangement, both cell and amplifier are utilized to best advantage.

For example, a presently available cell used in conjunction with a single junction-type transistor will operate a conventional dc relay at a rate exceeding several hundred operations per second—with incident light levels of the order of a few footcandles. This device is extremely simple, consisting of nothing more than the cell, the transistor, and a relay connected to a suitable dc supply.

Waves

The whole field of communication is the conversion of sound waves into electric or radio waves and back to sound waves.

One of the most fascinating studies now under way is aimed at the development of a telephone calling and switching system that operates directly from the spoken number. Just pick up the receiver or press a button, speak the exchange and number wanted, and you "get your party."

A modification of telephone switching from a spoken number is the automatic typing of a spoken message. Some progress has been made in this direction. Professor John Kessler, Acoustics Laboratory, Massachusetts

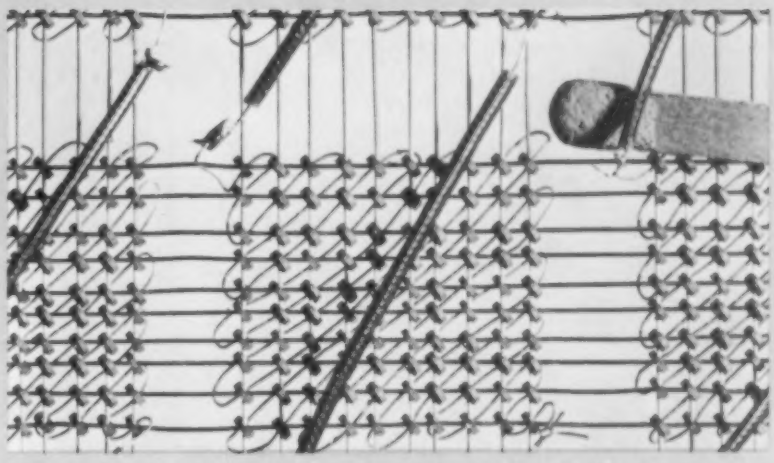
Magnified model of the two basic elements of experimental RCA Atomic Battery, which by means of a new method makes it possible to convert atomic energy directly and simply into small but usable quantities of electrical energy. Cylinder (at left) has thin coating of radioactive material on its face next to transistor-like water. Radiated electrons bombard water to release more electrons for battery current and voltage.

Dr. Albert C. Titus, Carbon Products Laboratory, General Electric Company, using x-ray absorption apparatus to analyze impregnated carbon brushes without destroying them. Ordinary brushes wear out 10,000 times faster when moisture is absent. Certain metallic salts added to carbon provide brush lubrication under all conditions, if the proportion of salts is exactly right. The x-ray absorption test tells if it is.

Institute of Technology, reports that work is being done on a digit recognizer.

Radio waves are crowding the air to the point of interference. Hence the research work to determine the minimum width of band needed for identification of speech elements. It will of course be necessary to decipher the message on the receiving end by automatic means to make the message intelligible. By this system it is expected that it will be feasible to transmit more messages simultaneously in a given wave band.

At the Burroughs Research Center in Paoli, Penna., Mr. Saul Kuchinsky states that one important phase of their research has been the use of an electron beam for multiple distributing and switching functions of one-millionth second operation. A combination of both magnetic and electric fields proved to be the answer. A magnetron beam switching tube was designed which produces ten-channel switching. Fewer channels can be used if desired. Through interconnection of tubes, the number of channels can be increased to satisfy any requirement. For example, 5000 channels are readily feasible. This is basically a new device which will eventually obsolete many mechanical and electro-mechanical switching devices now being used. Although present outputs are in the order of milliamps, indications are that in the near future currents in the order of amperes may be switched electronically. Future possibilities are: (1) Use in place of relays in industrial controllers; (2) use in telephone circuits instead of the selector switches; (3) use in place of automobile engine distributors; and (4) use for extremely high-speed switching or computing up to 100-million operations per second, which is far in advance of developments to date.



Enlarged view of a section of a new magnetic memory device developed by Dr. Jan A. Rajchman, RCA physicist. Head of a paper match (right) shows relative size of the tiny magnetic cores that store information of the kind used in electronic computers. A core "memorizes" one bit of information when both the horizontal and vertical wires through its center carry an electrical signal. The common wire that threads through all the cores is used to "read out" an electrical pulse that may be created when an individual core is interrogated. Insulated wires (dark diagonals) link the common "read out" wire of one group of cores to another. The magnetic core memory was developed at the David Sarnoff Research Center of RCA, Princeton, N. J., to provide a high-speed and large-capacity memory to help solve problems too vast and too complex for present-day computers.

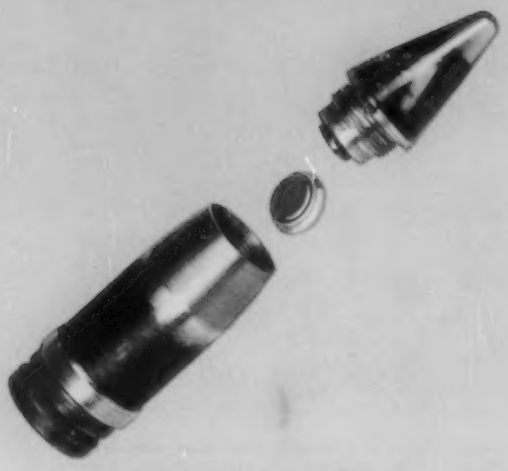
New RCA experimental high speed memory. Dr. Jan A. Rajchman, RCA physicist, examines the 10,000 tiny magnetic cores, woven on a wire mesh, that "memorize" in a few millionths of a second the kind of information used in electronic computer.

X-Rays Test Carbon Brushes for Electric Motors

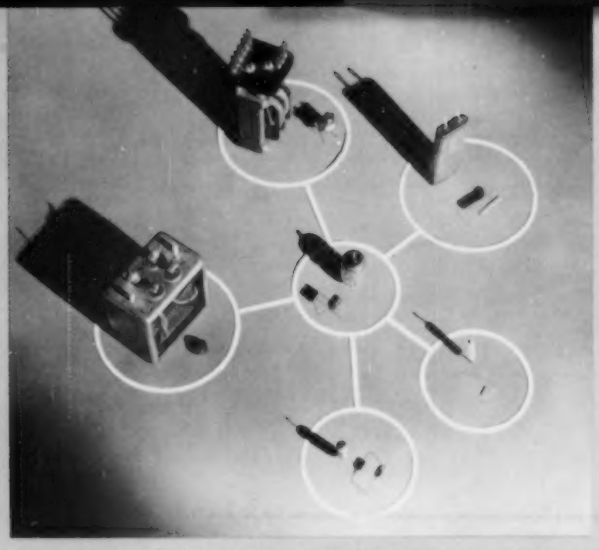
A technique using X-ray absorptions for analyzing impregnated carbon brushes without destroying them has been devised by Dr. Albert C. Titus of General Electric's Carbon Products Laboratory with the cooperation of scientists and technicians in the GE Research Laboratory.

Research Laboratory investigations by Robert Savage of G.E. Research had disclosed that long brush life is possible under climatic conditions prevailing over most of the world where there are sufficient water molecules in the air to "sit down" on the carbon brushes and provide the lubrication needed. Without this moisture, carbon brushes wear out 10,000 times faster than normal, in less than an hour instead of years. It was further indicated that such rapid wear could be expected to occur particularly at high altitudes where the required moisture is absent.

Here was an example of scientists anticipating a problem before it arose. A large bomber may have 400 or more assorted motors, generators, and other rotating electrical machines. Laboratory experiments showed that under the extreme conditions encountered by



A 20 mm. projectile equipped with transistor radio transmitter. The small button like object in center is the battery which powers the transmitter for about 200 hours. The transmitter is potted in plastics in the nose of the projectile. Use of the device is made by the U. S. Naval Ordnance Laboratory to study the flight properties of the projectile.



Examples of Miniaturization. A Bell Laboratories display of miniaturization, showing comparative transformers, capacitor, electronic tube and transistor, inductor and resistor.

stratosphere-flying aircraft, brushes might wear down and disappear as a smoke-like powder in as short a time as one hour. U. S. industrial scientists licked this problem by various methods, including the use of organic materials or metallic salts as impregnants in graphite. It was in connection with the use of these metallic salts to provide lubrication under all conditions that Dr. Titus' method of analysis was developed.

In order to promote long brush life the proportion of metallic salts to graphite had to be adjusted to within extremely close tolerances, neither too much nor too little. Too much caused brushes to overheat and fail to carry their load. Too little made them wear out almost as fast as untreated. It was necessary to find a quick nondestructive test that would indicate the exact proportion of metallic salts in a given brush material. Dr. Titus' method, using X-ray absorptiometry, is a solution. It is based on long-range theoretical work done at the General Electric Research Laboratory and elsewhere.

X-ray absorption is essentially an atomic process virtually independent of the chemical or physical state. Because this absorption rate is definite for any element, it was possible to determine the concentration of specific atoms present in a given sample. Routine measurements can be made quickly on gases, liquids, or solids.

Early uses for X-ray absorptiometry included determining the amount of calcium in teeth, the measurement of barium in glass and antimony in a silicate. etc. The technique has also been used for practical industrial problems such as finding the amount of tetraethyl lead in the preparation of leaded gasoline, measuring the thickness of steel strip in a rolling mill, and now, the routine analysis of impregnated carbon brushes.

GE's X-ray absorption apparatus became possible through use of the multiplier photo tube. Painting a photo tube with a phosphor (zinc sulfide) enabled the conversion of X-rays into visible (blue) light, thus adding versatility to the tool. Applied to chemical analysis, it enables one to swiftly irradiate any given sample with a known X-ray beam strength, measure the amount of penetration and make comparisons. The latest GE model has the advantages of speed in performing such analyses and of accomplishing this without destroying the sample.

Crystals and Crystal Gazing

The piezoelectric effect of the crystals of certain materials has been known for quite a few years. Put pressure on the crystal and an electric charge develops on the surface. That is where the crystal gets its name, piezo, from the Greek word for pressure. Even the slight pressure of sound waves creates minute currents that can be amplified and thereby detected.

Conversely an electric charge on the surface of the crystal causes the crystal to change its shape. Indeed, by virtue of this property of the crystal, alternating currents can be converted into sound waves. On such simple facts have been built the sound recording industry, submarine detection devices, and controls for radio broadcasts.

However, some crystals have an even more spectacular property. They become luminous when streams of energy such as ultraviolet light, electron beams or X-rays impinge upon them. This is the basis of the operation of the fluorescent lamp, the television screen, and the watch dials that glow in the dark. They are all made of layers of tiny crystals that convert invisible energy into "cold" light. The short waves of the invisible energy are converted into longer visible waves.

Electronic Light

David Sarnoff, Chairman of the Board of the Radio Corporation of America announced last fall that one of the by-products of television research may be "electronic" light. Quoting Brig. General David Sarnoff:

"In the context of this Diamond Jubilee of Light, what interests us most directly is the evidence already available that the light amplifier is not too far out of reach. I am speaking of light which is produced directly within a thin layer of electrically active material. Already I have seen this light amplifi-

cation experimentally, in ratios of more than 20; and further progress is certain to be made.

"What are the potentials of practical use of such a revolutionary development as the light amplifiers? It is not possible to forsee all of them. Before a new invention reaches the stage of practical application often, as we know from experience, the most significant uses are not immediately apparent.

"I am convinced that electronic amplification and conversion of light will enrich life for all of us. A first benefit from this research will be bigger and brighter television pictures in the home. I believe that the TV tube of today will eventually be eliminated. It will be displaced by a thin, flat screen like a picture on a wall. Or, it may be an easel-like frame that will set on your living room table and, being portable, can be moved to any other part of the room or house. If desired, the same program could be received on a number of screens in different rooms of the house.

"The pictures could be controlled from a little television box no bigger than a jewel case or a cigar box. No cabinet will be required. The television box will contain all the controls—tuning, volume, light, station selector—and a knob will enable you to make the image larger or smaller, and in black-and-white or in color to suit your eye and your mood.

"Television, however, is only one of the avenues through which electronic light will flow into daily life. Right down the line it will provide substitutes for present types of light used for illumination.

"In other areas, the electronic light amplifier may be expected to lead to devices which will make vision possible in darkness. These will add greatly to the safety of our transportation on land, at sea and in the air. The perils of night driving, too, are likely to be reduced and perhaps abolished by such electronic devices providing far-reaching light without glare.

"In short, the sky is the limit in imagining the future of electronic light. The one certainty is that, like other major scientific innovations in the past, it will open roads to improvements on existing products and processes, and will give birth to entirely new instruments, appliances and services.

"The fact that electronics and atomics are unfolding simultaneously is a portent of incalculable changes ahead. Never before have two such mighty forces been unleashed at the same time. Together, electronics and atomics are fated to dwarf even the industrial revolutions brought by steam and electricity."

In referring to the need for social progress to keep pace with scientific advances, General Sarnoff said: "Whether the splitting of the atom can be called 'progress' will depend, in the final analysis, on whether we can find the wisdom to direct the released power into channels of peaceable and constructive use. . . . . The secret of progress is in man himself."

Tiny crystals a few thousandths of an inch thick and a quarter of an inch square with remarkable memory properties have been developed by Bell Telephone Laboratories. Made of barium titanate, these crystals can remember bits of information for indefinite period. Note the fine electrodes which carry the information, in the form of electrical charges, to the crystal. Words, sentences or a series of numbers can be coded and remembered by this crystal until needed.

Magnetism

Exhaustive studies of both the well-known and the lesser known magnetic materials are being made to learn more about the nature of magnetism. By examining magnetic materials with high power instruments, researchers at Carnegie Institute of Technology hope to determine just why materials are magnetic—in the hope that new alloys having higher magnetic properties might be developed. According to Dr. J. E. Goldman, this may lead to a revolution in electrical machinery and small magnetically operated components. Within ten years, he estimates that the magnetic properties of electrical steels will be increased about 20 per cent.

At the General Electrical Research Laboratory, the role of oxides as magnetic materials has received considerable attention. It has been found that mixtures of FeO and Fe_2O_3, or the oxides of other metals, have small electrical conductivity, and the maximum flux density, about one-fourth that of pure iron, is 5,000 gauss maximum, but generally only 3,500 gauss. These oxide materials are excellent for high frequency transformers because their low electrical conductivity reduces the eddy currents which limit high frequency permeability in metals. And because the eddy currents are low, the bandwidth is larger.

When fabricated into magnetic memories for computers, such as the Whirlwind digital computer at MIT, these magnets are about the size of the head of a pin. In making magnets from oxides, orientation is of prime importance. For example, one part borium oxide to six parts Fe_2O_3 – powdered, pressed, and sintered—gives 800,000 to 900,000 BH with random orientation. When aligned, the same material gives 2,500,000 to 3,000,000 BH max.

In the field of permanent magnets, GE scientists are studying a magnet made of particles of iron, or other magnetic materials as well, held together in a durable matrix. Each particle, which is a strong magnet by itself, is oriented in the same direction and is separated from the others. Dr. John Fischer, manager of the physical metallurgy division, states that it is theoretically possible to develop magnets that are five times as powerful as Alnico 5.

Work is still underway to orient the crystals in sheet steel magnetic material. It can be done, but the drawback is cost. Simpler methods are being sought. If successful, it will mean vast improvements in transformers, motors and generators.

With respect to the development of more efficient and more powerful magnets, researchers are now making use of instruments based on the nuclear magnetic resonance effect.

° ° °

This presentation merely skims the scientific progress being made in unravelling the mysteries of electricity.

Above—At the Leningrad State University, a professor delivers a lecture on physics. Note the large number of girl students.

Below—Students of the evening department of the Siberian Institute of Metallurgy in Stalinsk during a session of practical studies in the laboratory.

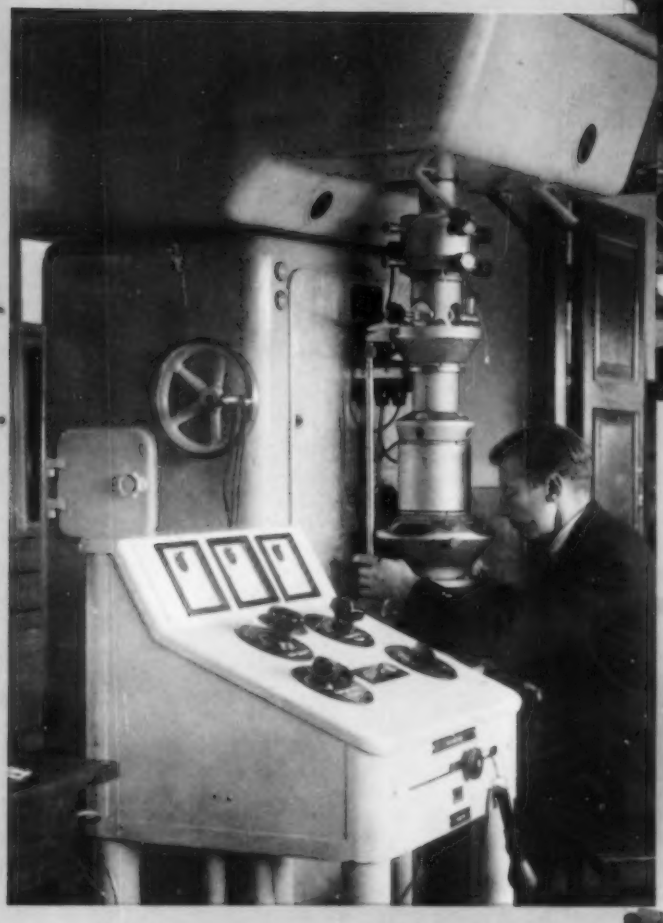
The training of future aircraft and engine builders in Moscow. Here are third year students attending a lecture on aero-dynamics.

Technical Training in the

UP UNTIL A FEW YEARS AGO, the quality of the Russian scientist, from the American viewpoint, was not worth worrying about. But since then, the performance of some of the Russian planes and implements of war, their huge productive effort, and the development of nuclear weapons and power have made U.S. scientists sit back and take notice. And well they might. The Russians have long realized their inferiority in science, compared to the Western countries, and have set out to overcome this deficiency. Back in 1931, Stalin is reported to have said, "We are from 50 to 100 years behind the advanced countries. We must make good the distance in ten years. We must ourselves become experts; we must turn to science."

Stalin all but made good his promise, and U.S. educators will testify to this fact. M. H. Trytten, director of the Office of Scientific Personnel of the National Research Council, says, "America is rapidly falling behind Russia in the race to produce engineers." Dr. John T. Rettaliata, president of Illinois Institute of Technology, states, "American supremacy in science and technology is seriously threatened by a rapid build-up in the supply of engineers in Russia." Dr. Rettaliata also says that, "While the U.S. has some 500,000 engineers and 200,000 scientists, compared with Russia's estimated 400,000 and 150,000, the Soviet Union has been expanding training in these fields more rapidly than the United States."

Presently, Russia has 175 technical schools of the university level in more than fifty cities, with a total student enrollment of over 300,000. Furthermore, Russian leaders expect to increase this number for years to come. The United States, on the other hand, has just about half this number of engi-



Above—Russian students shown running a test in the electrical machinery laboratory of the Molotov Automobile and Highway Institute in Moscow.

Below—Two university students in the city of Voronezh working on their diploma projects in analytic chemistry in the spectral analysis laboratory. In this city there are eight schools of the university level.

An electron microscope in use at the Moscow Power Engineering Institute. The Russian 5-year plan expects an increase of almost 35 per cent in the output of specialists of all kinds.

Soviet Union

neering students presently enrolled. Looking at it another way, the Soviet Union has increased the number of engineering graduates from 29,000 in 1948 to more than 50,000 in 1954. In contrast, the United States in 1954 graduated only 19,000 engineers.

In addition, the Russians have about 3,500 technikums, or technical institutes, offering three and four years of study. These schools have well over 1,000,000 students, and are now turning out 350,000 graduates annually, of which 50,000 are engineering technicians. According to some U.S. educators, the Russians have an advantage in this respect, because their technical schools in most cases are better than ours, and the graduates of these schools do a large share of the supporting engineering work, while in the U.S. trained engineers' talents are often wasted doing much of this work.

As to the quality of Russian engineering training, it is generally realized that it is no worse than that of the average U.S. engineer. Russian engineering training lasts from 5 to 5½ years, and is based on about 5,000 hours of classroom and laboratory instruction. It has been estimated to be somewhere between our bachelors' and masters' degree. Most of the program during the 5½ years is at the expense of the humanities, and is devoted to narrow spcialization. In the major subject matter, the education is equivalent to beyond the masters' degree level in the U.S. today, where the scientist and engineer is prepared for civic as well as professional duties. Consequently, more of the humanities and liberal arts studies are included.

As for graduate study, last year Russia produced as may Ph.D's as the United States, but in the U.S., these degrees ran three to one in favor of the humanities, while in Russia they were three to one in favor of science and engineering. Russia gives heavy emphasis to graduate study, particularly in the sciences, while in the U.S., universities have difficulty retaining students because of some draft board policies. Dr. Rettaliata feels that, "The

Above—The Urals Polytechnical Institute in Sverdlovsk. Specialized training here is in metallurgy, machine design, and energetics. One of the buildings of the institute is shown.

Right—Inside the Urals Polytechnical Institute shown above, is the materials testing laboratory. This school is considered the U.S.S.R.'s largest technical institute.

best candidates for future scientific and engineering leadership must have training. Real contributions toward fundamental research are made in the graduate field, and it is disturbing when students who have the ability and desire to pursue advanced study are prevented from doing so. Engineers and scientists constitute less than one-half of one per cent of our population. Yet, we are relying on this limited group to further the advance of our living standards, create our military equipment, and in general, be responsible for our national security."

In Russia, science is stressed from the grade schools on up. There is a healthy diet of arithmetic, algebra, geometry and the natural sciences. Following this, in the secondary schools, emphasis is strong on science and mathematics for all students. About 40 per cent of the curriculum is devoted to subjects in these fields, and there are no electives. By way of contrast, only about 20 per cent of the U.S. high school graduates have had general science courses, and only six to eight per cent have had physics and chemistry. Too many high schools are drifting toward a more general education program which prepares fewer graduates to take up scientific and engineering studies in college.

According to leading educators in the U.S., the problem of greatest concern to the engineering and scientific professions rests in the secondary schools. The quality and quantity of mathematical and scientific instruction that high school students receive disturbs most of the scientists. In some cases the instructors have had little training in these fields. The result is that the pupils who are qualified do not get the inspiration necessary to continue in this profession. And those who are interested, do not get the necessary basic training to carry them over to college work.

The demand for able scientists and engineers has far exceeded the supply since 1951. With the minimum demand of about 30,000 per year, a shortage is being created that will grow greater each year. Because of this, many engineering, physics, and mathematics teachers are encouraged by attractive salaries to join industry.

According to the accompanying table, the number of college graduates trained for the teaching of high school sciences has fallen 56 per cent in the last four years.

Thus, in 1950 there were 9,096 college graduates prepared to teach high school science; in 1954 this figure had dropped to 3,978. Estimates have placed the high school enrollments to increase from 7-million to 10-million in the next ten years. With future scientists and engineers receiving their en-

Left—South-China's Medical College in Canton is one of the largest medical schools in South China. Shown here is the new anatomy building.

Below—The new library of the South-China Engineering College, the largest institute of its kind in South China. Its five engineering departments are: chemical; mechanical; tele-communicational, civil, and architectural.

couragement and education at this level, the decreasing number of science teachers makes the danger quite obvious.

The continuing lack of enthusiasm for the scientific professions in the U.S. secondary schools cannot help but effect the number of engineers and scientists that will be available in the future. The Russian high school boy, when it is time for him to make his choice, is always influenced by the prestige, built up by the state, of the engineering and science fields. Newspaper headlines stress scientific achievements, not the activities of film stars or baseball teams. Besides this, many books depict the engineer or scientist not the detective or athlete as the hero.

Russia's program to train technicians and engineers is not limited to the Soviet Union alone, but has expanded to all the satellite countries and China. It has been reported that China now has about 250,000 students taking higher education. About 60 per cent of these are in engineering, science, health and agriculture. China has 2-year engineering courses, and is graduating about 25,000 students each year. Besides this, roughly 5,000 scientists a year are graduating from the four or five year courses. Technical school enrollment is also increasing.

Will communist countries repeat the history of Germany in the development of unmatched engineering and industrial achievements? This would make Russia so powerful in science and engineering that by concentrating this might on military objectives, it could dwarf the Germany of 1940 in the production of weapons.

The proof of Russian science and technology rests with their accomplishments. And of these, we know that they possess the Atomic bomb and just recently have exploded a Hydrogen bomb.

Declining Number of Science Teachers Produced

	1950	1951	1952	1953	1954
Mathematics	4,618	4,118	3,142	2,573	2,281
General Science	3,009	2,772	2,216	1,664	1,505
Chemistry	1,660	1,342	842	662	608
Physics	954	578	373	357	259

Courtesy N. Y. Times

A Pillar of Fire and a Cloud . . .

The mushroom of spent fury—the death and destruction it implies repels the gaze that its magnificence and majesty attracts.

FOR MANY YEARS scientists were aware of the tremendous power wrapped up in the atom. How could it be liberated? How could its magnitude be calculated? How could that power be controlled?

The first step in the unraveling of the mystery of the atom was to find out all about the atom itself. What is it? How is it constructed? What holds it together? How can it be torn apart?

It was his observation of the behavior of smoke rings that led Niels Bohr, famous Danish physicist, to the establishment of the now famous theory of the structure of the atom. Niels Bohr noticed that smoke rings approaching a wall that was perpendicular to the line of the travel of the ring, never reached the wall. As the ring came nearer and nearer to the wall it grew bigger and bigger and finally disintegrated. Niels Bohr asked himself why. Delving deeper and deeper into this question and following the logical lines of reasoning that only a scientist could understand, Niels Bohr finally in 1916 came up with a startling answer. Atoms are subminiature solar systems, each atom consisting of a nucleus or sun composed of protons and neutrons with planets called electrons swirling around the nucleus in well defined orbits and patterns.

Presumably, if it were possible to chip a particle off of the "sun" or the nucleus, it would throw the whole atomic solar system out of balance. The power of the nucleus to hold the electrons in their appointed paths would be diminished. The chipped off piece of nucleus would rush off, presumably drawing some of the electrons along with it. Protons, neutrons and electrons would rush around randomly and in confusion seeking to reorganize new stabilized atomic solar systems. It would be a veritable holocaust.

Out of the confusion there would be established new atoms, these creating other materials. But by the laws of chance and physics, as the scientists figure it out, the sum total of all of the mass of material, that finally results through the reorganization of the new atomic solar systems would be less than the mass of the original material. And that is what actually happens. The Newtonian law of the conservation of matter is broken.

What hapens to the matter that disappears? Dr. Albert Einstein furnished the answer. The matter that disappears, reappears in the form of energy. How much energy? An amount equal to the kinetic energy of the disappeared mass when speeding at the velocity of light, was Einstein's answer. Thus, if one pound weight of material disappears, it reappears in a bomb explosion, releasing one-half a million billion foot-pounds of energy.

It is not necessary to release the atomic energy in the form of a blast. When used in the generation of power, disintegration of the fissionable material is controlled so that all of its energy is converted into heat at a slow enough rate to be usable.

The disintegration of one pound of fissionable uranium is equal to the burning of 1,300 tons of coal. Thus, as a fuel the uranium weight for weight delivers more than two million times as much energy as is obtained from the burning of coal.

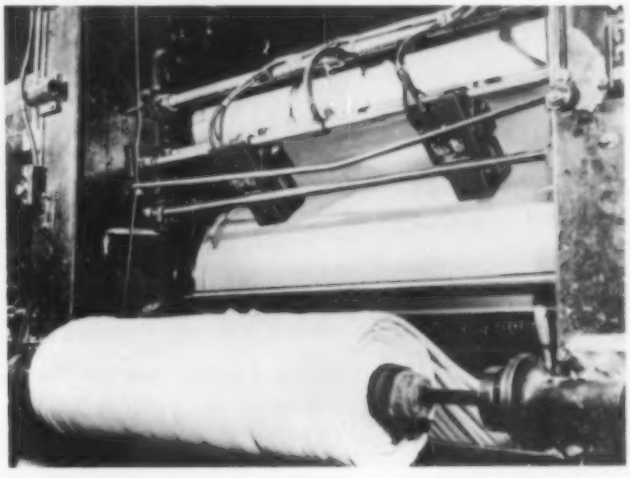
Just as Faraday's discovery of the generation of induced electricity focused attention upon electricity primarily as a new form of energy for supplying heat, light and power so is the thinking about atomic energy concentrated likewise. However, just as electricity is serving mankind in many ways other than as a source of primary energy, so will atomic energy serve mankind in many ways undetermined today.

On the opposite page are shown just a few of the uses to which atomic energy is being put to use. What other uses might there be? As a new tool for scientific investigation, nuclear physics gives great promise of opening many new fields of knowledge. Its use as a source of power has hardly been scratched. Its possibilities in medicine and surgery have already been indicated to some extent. But the great boons to mankind that are hidden behind the curtain of the future cannot even be guessed.

Where Will It Lead Us?

● Here are pictured a few of the results already obtained. Will this lead man out of his moral wilderness, as in ancient times ". . . . . by day time a pillar of a cloud, and a pillar of fire by night". . . . . led a nation out of a physical wilderness?

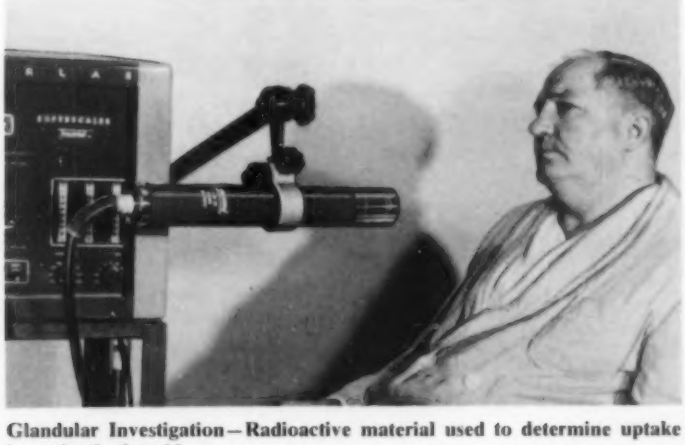
Nuclear Powered Vessel – The U.S.S. Nautilus General Dynamics Corp.



Production Control – Beta ray gauges measuring thickness of rubber. Tracerlab, Inc.

Non Destructive Testing – Radioactive source and remote control apparatus
Anton Electronics Laboratories

Wear Testing – Placing a radioactive gear on wear testing machine.
Tracerlab, Inc.



Glandular Investigation – Radioactive material used to determine uptake in patient's thyroid. Tracerlab, Inc.

Radioactive Medical Treatment – Measuring radiation dose in simulated cell containing radioactive material.
Columbia-Presbyterian Medical Center

Behind the Curtain That Veils the Future

There can be no stop to man's progress in scientific achievements and developing new products and services for our material civilization ✳ Until the physicist has ferreted out the last fact and formula from the limitless fields of knowledge ✳ Until the chemist has made his last analysis ✳ Until the metallurgist has tested his last alloy ✳ Until the design engineer has applied all knowledge, every known material, each available device ✳ Not until the mind of man has ceased to function can material progress stop.

"When I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is man that thou art mindful of him? . . . Thou madest him to have dominion over the works of thy hands . . ."—PSALM 8.

Therein lies man's gravest responsibility

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Capital Spending Plans for 1955 . . .

Here is Good News About Business Prospects

In 1955, American industry is now planning to spend within 5 per cent of the amount it is spending this year on new plant and equipment. This is the tensely awaited result of a check-up just completed by the McGraw-Hill Department of Economics.

Hundreds of companies, by far the largest number in the eight-year history of these McGraw-Hill surveys, cooperated in the check-up. Combined, they represent 29 per cent of all industrial employment and over 60 per cent of employment in the industries where capital investment is highest. Such a broad cross section constitutes a reliable gauge of the plans of industry as a whole.

PLANS FOR CAPITAL INVESTMENT

	MILLIONS OF DOLLARS			Percent Change
	1953 ACTUAL*	1954 ESTIMATED*	1955 PLANNED	1954-1955
All Manufacturing	$10,026	$ 9,249	$ 8,598	—7%
Petroleum Industry†	4,600	4,875	4,920	+1
Mining	506	380	311	—18
Railroads	1,312	851	769	—10
Other Transportation and Communications	2,954	2,922	2,640	—10
Electric and Gas Utilities	4,548	4,274	4,206	—2
ALL INDUSTRY	23,271	21,784	20,727	—5

*United States Department of Commerce; Chase National Bank; McGraw-Hill Department of Economics

†Petroleum refining, included under both "All Manufacturing" and "Petroleum Industry," is included only once in the total

What is the meaning of these plans, detailed by the table below, for capital investment next year? Is it good or bad news, so far as it concerns the prospect of continuing prosperity? It is to this crucial question that this editorial is addressed.

Key to Prosperity

It is not only good but very important business news that American industry plans to spend in 1955 almost as much for new plant and equipment as it is spending this year. The reason it is important is that a high level of activity in the capital goods industries is universally recognized as a particularly potent ingredient of prosperity for the nation as a whole. A dollar spent for capital goods is spent again and again for wages and materials. Its stimulating effects, called by economists multiplying effects, move through the economy in much the same way that a pebble tossed into a pond creates a widening circle of ripples. This is one reason why there is such intense business interest in the surveys of plans for capital investment.

Here are the principal reasons why the results of the McGraw-Hill survey are a good omen for continuing prosperity:

1. American industry is demonstrating that it does not need the stimulus of war-created shortages, or a rearmament boom, in order to maintain a very high level of capital investment.

The slight decrease now planned for 1955 will still maintain a level only about 11 percent below the all-time peak attained in 1953 under the stimulus of a defense expansion boom.

2. Capital investment promises not merely to stabilize at a high level, but actually to increase as 1955 goes on and thus give renewed stimulus to business.

The level of investment now planned for 1955 by *industry* — manufacturing, petroleum, mining, transportation, communications and utilities — is within 5 per cent of 1954. Contract awards for *commercial* construction — stores, office buildings, warehouses and other service establishments — as compiled by the McGraw-Hill publication ENGINEERING NEWS-RECORD, indicate a substantial increase in 1955. Thus total capital expenditures by *all business* may be very close to this year's total.

Actually, in the fourth quarter of 1954, business capital expenditures, as reported to the U. S. Department of Commerce, are down about 2.5 per cent from the average for the year as a whole. So there is a good chance that during 1955 the annual rate of capital investment will rise above this present level.

Effect of Tax Changes

The plans reported by the McGraw-Hill survey are preliminary plans, reported at the beginning of the period of business budgeting for 1955. As budgets are completed, new projects may bring the total expenditure that is planned even closer to this year's figure and thus make an even greater contribution to continuing prosperity.

But it also cannot be too strongly emphasized that these are plans; they are not accomplished investments. As such they have the vulnerability to changed conditions that characterize any plans.

There is some indication in the results of the McGraw-Hill check-up that one change in conditions recently made by the United States government has had an important stimulating effect on plans for business investment next year. It is a liberalization of the allowances for depreciation. Apparently encouraged by this provision, most of the smaller companies are planning to maintain or increase their purchases of new equipment next year, whereas during the past three years their expenditures have been declining. This is obviously a development that strengthens our economy.

A government insensitive to the key importance of capital investment by business, both in providing prosperity and in raising our standard of living, might easily destroy the present plans. One of the easiest and surest means to do this is excessive taxation of business profits which are the key ingredient of business investment. Whether the extraordinarily constructive program recently enacted by the federal government in the field of business taxation can be sustained remains to be seen. **If it can be sustained, the remarkably cheering plans of business for capital investment in 1955 can readily become firm foundations for a continuing prosperity.**

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.

Motor Overload Relays

Fundamentals of operation and application of bimetal thermal overload relays presented as a guide in selecting the proper type and rating; for both normal and unusual service such as non-standard ambients and short-time-rated motors; determining tripping time and coordinating it with short-circuit protection.

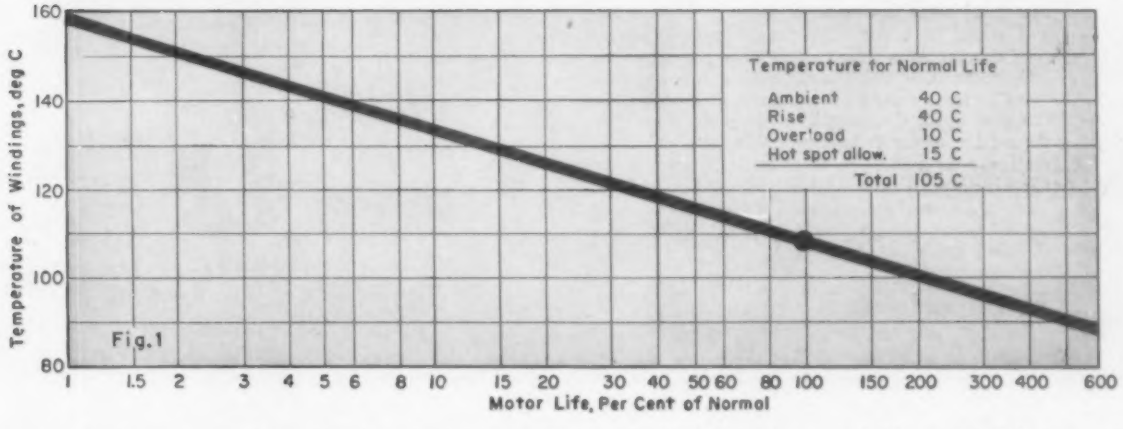

Temperature of Windings, deg C
160
140
120
100
80
Temperature for Normal Life
Ambient 40 C
Rise 40 C
Over'load 10 C
Hot spot allow. 15 C
Total 105 C
Fig. 1
1 1.5 2 3 4 5 6 8 10 15 20 30 40 50 60 80 100 150 200 300 400 600
Motor Life, Per Cent of Normal

Fig. 1—How motor winding operating temperature affects motor life. Normal expected life at 105 C is 20 years.

JACK SHEETS

General Purpose Control Department
General Electric Company

COST ADVANTAGES have influenced machinery designers to apply motors as closely as possible to their maximum full-load rating. This increases the need for adequate motor protection. Bimetal overload relays are widely used for this protection because of reliability, simplicity of design, and ready adaptability. The design problem is to select an overload relay which will permit the motor to carry full load but, in the event of sustained overloads, disconnect the motor from the line before it is damaged.

Class A motors are rated to give satisfactory operating life with a stator temperature not exceeding 105 C. Continuous operation of the motor above or below this temperature will affect life, as shown in Fig. 1. General-purpose motors (40 C rise) are designed to operate at 115 per cent load in a 40 C ambient without exceeding the 105 C temperature. The extra 15 per cent capacity is available as a "service factor". Motors rated 50 C or 55 C rise do not have this extra capacity.

Momentary higher temperatures (not to exceed 190 C) do not adversely affect the life of the motor and are allowable on starting or plugging. Thus, an overload protective relay must permit high currents for a short time, while protecting the motor on sustained overloads of smaller magnitude.

The bimetal overload relay, Fig. 2, accomplishes this dual function by means of a heater element which is con-

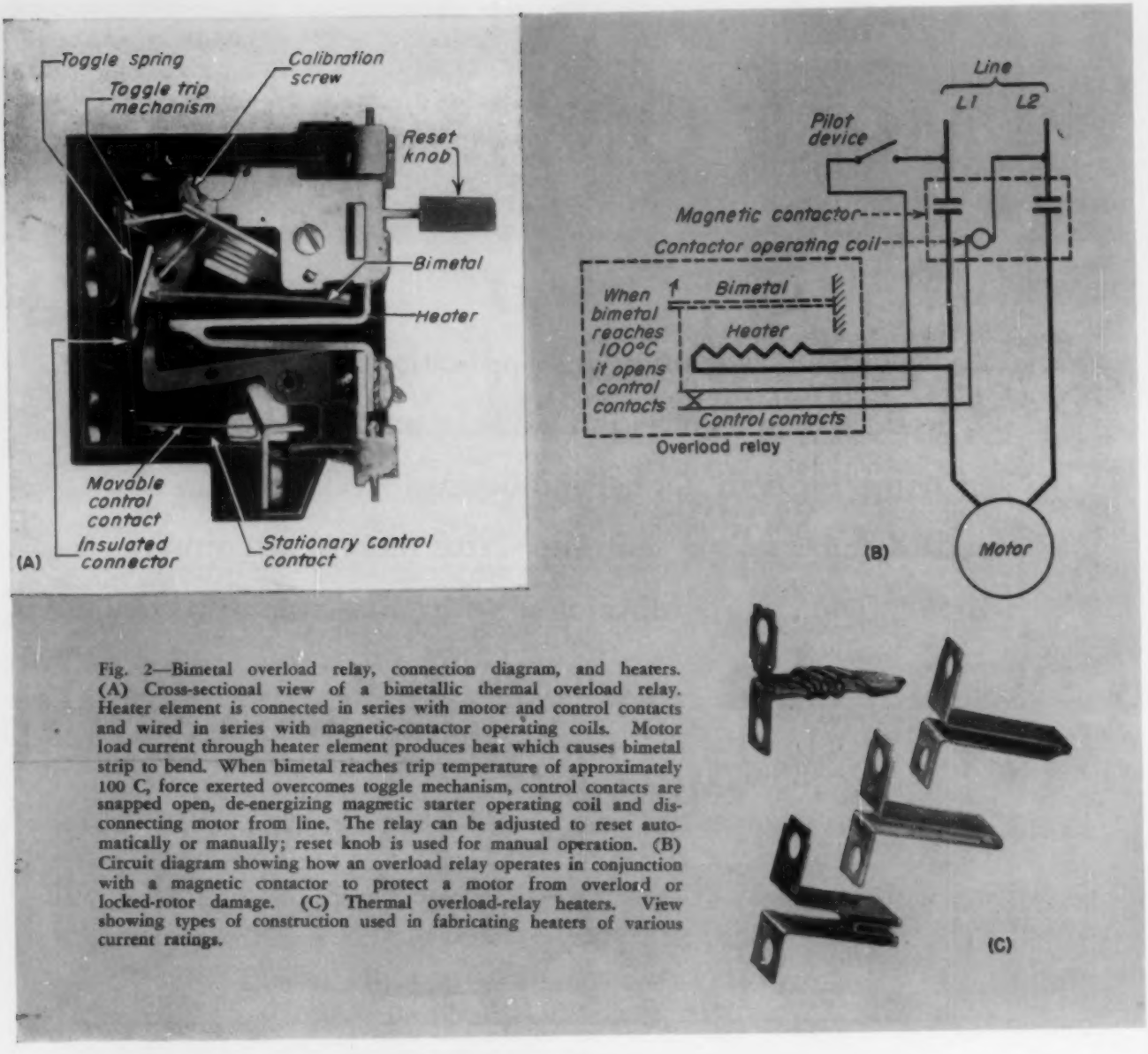


Fig. 2—Bimetal overload relay, connection diagram, and heaters. (A) Cross-sectional view of a bimetallic thermal overload relay. Heater element is connected in series with motor and control contacts and wired in series with magnetic-contactor operating coils. Motor load current through heater element produces heat which causes bimetal strip to bend. When bimetal reaches trip temperature of approximately 100 C, force exerted overcomes toggle mechanism, control contacts are snapped open, de-energizing magnetic starter operating coil and disconnecting motor from line. The relay can be adjusted to reset automatically or manually; reset knob is used for manual operation. (B) Circuit diagram showing how an overload relay operates in conjunction with a magnetic contactor to protect a motor from overlord or locked-rotor damage. (C) Thermal overload-relay heaters. View showing types of construction used in fabricating heaters of various current ratings.

nected in series with the motor. A bimetal strip adjacent to this heater trips a toggle mechanism when the temperature of the bimetal reaches a preset temperature, usually about 100 C. This opens the circuit to the operating coil of the starter contactor and disconnects the motor from the line. Interchangeable heaters with different current ranges adapt the relay rating to the particular motor.

HEATER RATINGS

The least current which, if maintained for an extended period of time, will ultimately trip the relay is known as the "trip current". Standard ratings are established in a 40 C ambient to be consistent with motor-rating procedure. As the bimetal is activated by heat, any environmental conditions producing heat will affect the heater rating; and a given heater rating will depend on the equipment with which it is used. Normally, two trip-current ratings are established, namely:

1. Open relay and open starter—this rating is applied when the relay is used alone on an open starter or on a starter in a large enclosure.

2. Enclosed starter—this rating is used when the relay is part of a starter mounted in a small enclosure.

Fig. 3(A) illustrates a relay mounted alone. The only heat activating the bimetal is produced by the motor current through the heater. If this relay is part of a magnetic starter as shown in Fig. 3(B), heat from the coil of the magnetic contactor, wiring, and contacts add to that produced by the relay heater. A smaller current in the heater will produce enough heat to trip the relay. If the relay is part of a starter mounted in a small enclosure, as in Fig. 3(C), heat from both the starter components and the heater are retained inside the enclosure. Even less heater current will trip the relay.

Choosing a heater for ordinary applications is simplified by converting the heater trip-current rating into a range of motor full-load currents with which the heater can be

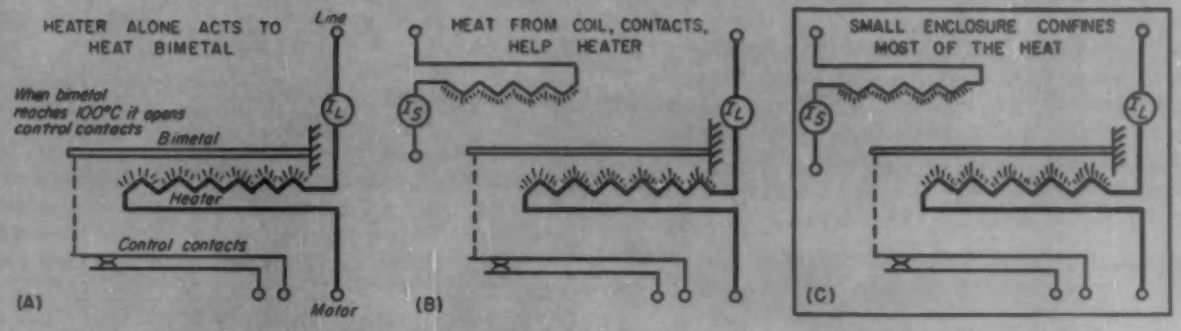


Fig. 3—Effect of three ambient environments in which relay may be mounted. (A) Relay is open. (B) Relay on open magnetic starter. (C) Relay on magnetic starter in small enclosure.

Table I—Portion of a Heater Table for a NEMA Size 2 Magnetic Starter

Heater	Motor Amps		Max Fuse Rating
	Min	Max	
A	16.4	18.5	80
B	18.6	20.7	90
C	20.8	22.2	90

Table II—Heater Correction Factors

Motor Rating		Correction Factor
Temp Rise	Duty Rating	
40 C	Continuous	1.00
50–55 C	Continuous	0.9
50–55 C	1 hour	0.8
50–55 C	30 min.	0.75
50–55 C	15 min.	0.7
50–55 C	5 min.	0.6

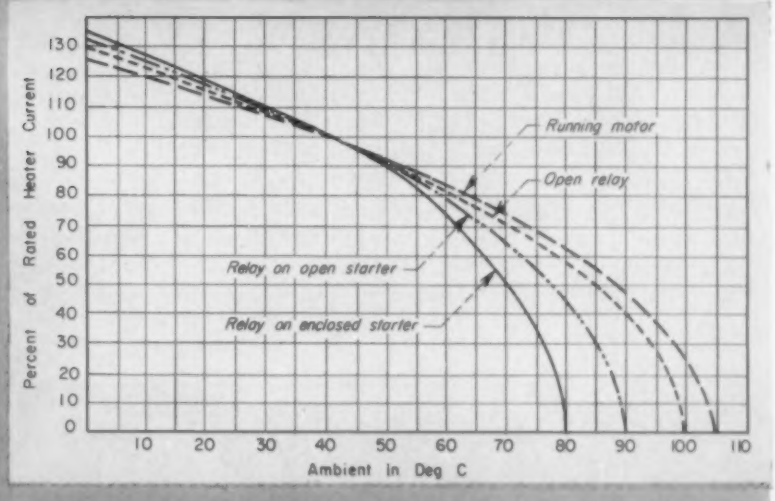


Fig. 4—Variation of motor load and heater current required to maintain standard 40 C motor-operating and heater temperatures in varying ambient temperatures. The running motor and relay curves are expressed in per cent of rated heater current at 40 C.

used. This is the "Motor Amps" column found in the typical heater table. As an example, a 7.5-hp, 220-volt, 3-phase motor with a full-load current of 20.1 amp would use heater B from Table I. The standard table is made up for 40 C rise motors. Because these motors have an additional 15 per cent service factor, actual heater tripping current is 1.15 times the max motor current in this column. Thus, heater B has a 20.7 amp max motor rating; the tripping current is 20.7 times 1.15 or 23.9 amp. Any heater tripping current can thus be found by multiplying the max motor current by 1.15.

The 50 C and 55 C rise motors do not have a 15 per cent service factor, and a correction must be made to the normal heater rating by multiplying the motor nameplate full load current by the proper correction factor found in Table II. This new current value is used to choose the heater from the heater-selection chart for the control equipment being used, resulting in a lower rated heater to provide proper motor protection. As an example, assume the 7.5-hp, 220-volt, 3-phase motor from the previous example has a 55 C rise rating. The nameplate current will be 20.1 amp as before, but in this case it must be multiplied by the 55 C correction factor of .9 from Table II.

$$20.1 \times .9 = 18.09 \text{ amp}$$

Using the 18.09 amp as a motor full-load current with Table I, the choice is heater A instead of B.

Short-time-rated motors must also be given special consideration. Heater-correction factors for these types are also found in Table II and are used as shown in the previous example.

A relay which protects a motor in a 40 C ambient will do so at other temperatures provided both motor and relay remain in the same ambient. If the relay and motor are in different ambients, the relay may trip at less or more than permissible full load. Corrections to minimize the possibility of premature tripping or damage to the

motor can be made using curves shown in Fig. 4. For example, if a 7.5-hp, 20.1-amp motor is in a 25 C ambient and the starter is in a 40 C ambient, the motor can carry 111 per cent rated load without exceeding its 100 per cent 40 C rated temperature. It is, therefore, desirable to increase the relay tripping current by 11 per cent to permit the motor to carry the additional load. Multiplying motor full-load current by a correction factor of 1.11 provides a new motor-current rating, or

$$20.1 \text{ amp} \times 1.11 = 22.2 \text{ amp}$$

Referring to Table I, this corrected full-load current falls within the 20.8-22.2 amp range. Heater C should be used instead of B.

TRIPPING TIME DETERMINATION

When it is necessary to determine heater tripping time under specific load conditions, tripping time vs current curves similar to those in Fig. 5 are used. Fig. 5 is a typical tripping curve for a relay which is part of an enclosed NEMA size 2 starter. For most applications, a band-type curve as shown in Fig. 5 is sufficient. An accompanying key sheet shows the band in which is given heater characteristic lies. Because relay operation is due to heater tripping current, the curves are based on heater-current rating rather than motor-current rating. The ordinate of the curve is in per cent of relay tripping current. Motor load current can be converted to per cent of rated tripping current using the following formula:

$$\text{Per cent heater tripping current} = \frac{100 \times \text{Motor load current}}{\text{Heater max motor amps}}$$

The tripping-time curve of Fig. 5 is based on 40 C ambient. When a different ambient is involved, correction must be applied to the relay tripping current by multiplying 40 C heater tripping current by the per cent rated current from the proper environmental curve of Fig. 4.

The following example of tripping-time calculations for a heater and motor in different ambients uses a 7.5-hp, 220-volt, 3-phase motor with a full-load current of 20.1 amp and a locked-rotor current of 121 amp. The motor is in a 40 C ambient, but the starter is a NEMA size 2 in a 30 C room ambient. The starter heater label shows a current rating of 18.6-20.7 amp for the heater used. The relay-heater tripping current at 40 C is the max motor amp times the 40 C motor factor of 1.15 or:

$$20.7 \times 1.15 = 23.8 \text{ amp}$$

The 30 C tripping current is 40 C current times 110 per cent rated current, read from the enclosed-starter curve of Fig. 3:

$$23.8 \times 1.10 = 26.2 \text{ amp}$$

Three-phase locked-rotor current for this motor is 121

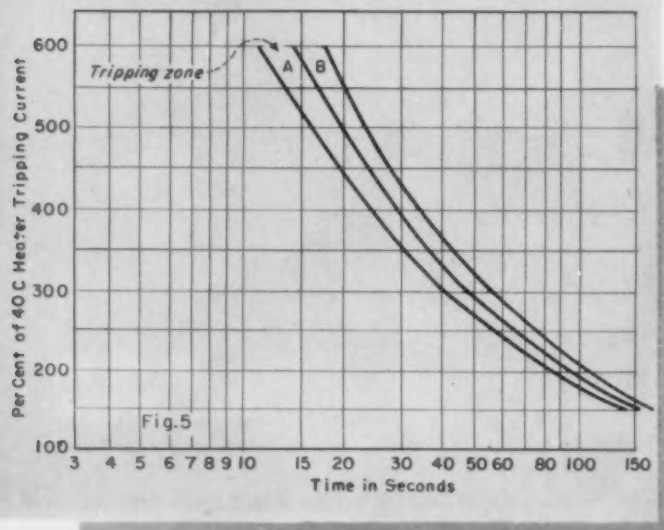


Fig. 5—Typical tripping time vs current curves for a thermal overload relay in a size 2 enclosed starter. Tripping zone indicates limits of tripping time at a given heater temperature.

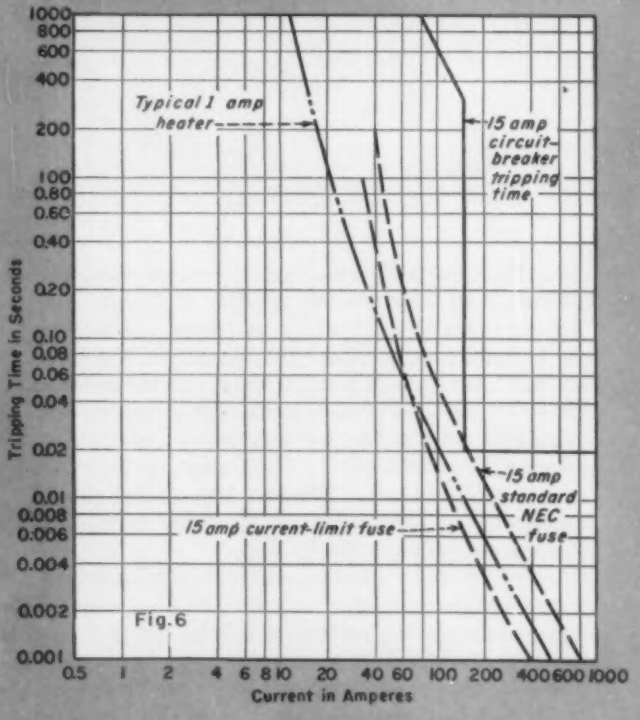


Fig. 6—Comparison of melting time vs current of a typical 1 amp relay heater and 15 amp short-circuit protectors which are greater than maximum recommended. The 15-amp NEC fuse or 15-amp circuit breaker offer no protection. The 15-amp current-limit fuse protects the heater only for short circuit currents in excess of 60 amps.

amp, and the per cent heater overload on locked rotor would be 100 times the locked-rotor current divided by the 30 C heater tripping current, or:

$$\frac{100 \times 121}{26.2} = 462 \text{ per cent}$$

Assuming that the characteristics of the heater falls in zone A of Fig. 5, it is found that with 462 per cent heater overload the relay will trip on three-phase locked rotor in 19 to 22 seconds. Single-phase locked-rotor amp are lower by a factor of .866 and overload is then:

$$\frac{100 \times 121 \times .866}{26.2} = 400 \text{ per cent}$$

With reduced overload, the tripping time (Fig. 5) is 24 to 29 seconds. While this is longer than three-phase tripping time a properly designed motor will withstand single-phase stall for a greater period.

NECESSITY FOR SHORT CIRCUIT PROTECTION

Thermal overload relays will trip before the heater is damaged on overloads up to 10 times motor full-load current; but they are not designed to provide protection against short-circuit currents. Unless proper branch-circuit protection is provided, severe damage to the heater can result. Results of improper short-circuit protection are indicated by the curves of Fig. 6 which show melting time vs current for a 15-amp NEC fuse, a new 15-amp current-limiting fuse, a 15-amp circuit breaker, and a typical heater rated at 1 amp tripping current. Using the 15-amp NEC fuse and 15-amp circuit breaker, the heater will melt before the fuse or circuit breaker, clears the short. On the other hand, if short circuit current is above 60 amp, the new current-limit fuse will melt before the heater is damaged. The curves of Fig. 7 shows that both 3-amp NEC and 6-amp current-limiting fuses will protect the heater from damage. Circuit breakers are not available in ratings less than 15 amperes and cannot properly protect heaters of this size.

QUICK-TRIP BIMETAL RELAYS

In new air conditioning integral-horsepower compressors. the motor is artificially cooled by passing the returning refrigeration gas or the coolant water over it. The harder the motor works, the more the refrigerant is pumped to cool itself. A similar problem is met in the case of the submerged-motor driving a pump. The load that can be carried by the running motor before it overheats is greatly increased, but the locked-rotor dissipating ability has not been increased. Therefore the overload relay must have special quick-trip characteristics shown in Fig. 8. A bimetal overload suited for this application uses the bimetal element as part of the heating element. The directly heated bimetal reacts faster under overload conditions and permits the use of automatic or manual reset.

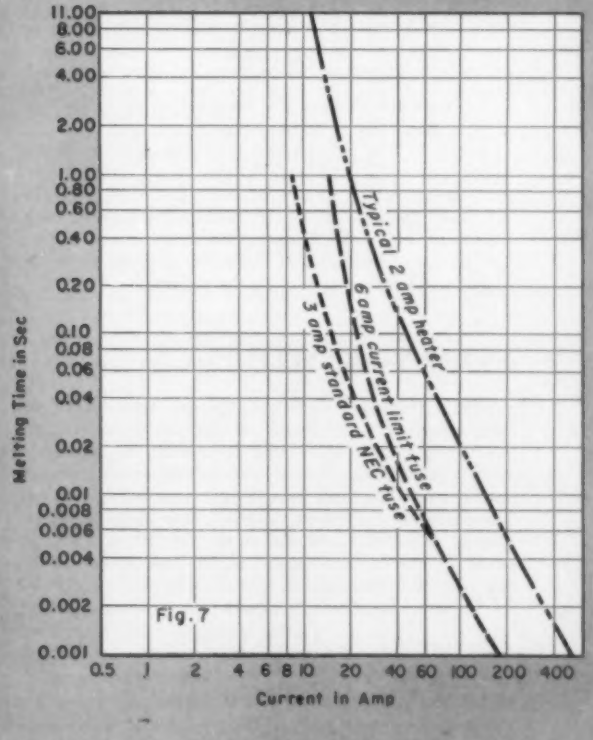
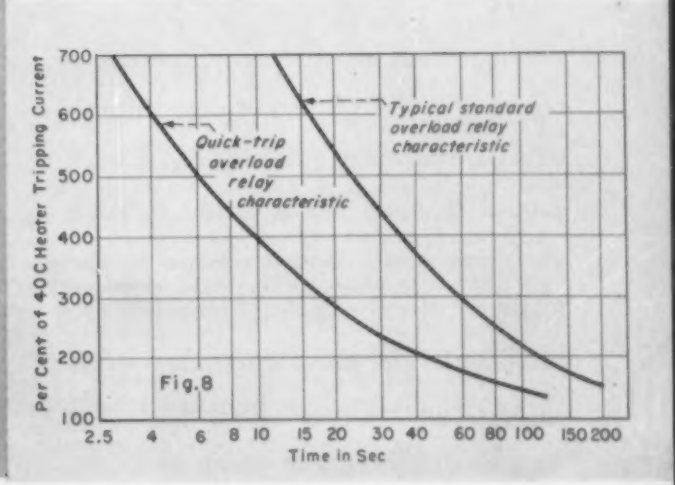


Fig. 7—Comparison of melting time vs current of a typical 1 amp heater and recommended fuse protection. The 6 amp current-limit fuse is smallest available size.

Fig. 8—Comparison of time-current characteristics for typical standard and "Quick-trip" overload relays.



Criteria For Selecting Experimental Stress Analysis Methods

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An important phase of any experimental stress analysis is that of determining which of the many available techniques should be used. As a guide in such problems, nine concepts basic to the selection of experimental methods are presented. The most important stress analysis methods are then evaluated with these concepts in mind.

BASE LENGTH

No experimental method can give the state of stress at a point. The measurement of the physical property which is related to stress always takes place on a finite volume, and the computed stress is the average of the stresses in that volume. In most cases, one dimension predominates and is called the base length.

The shorter the base length, the more accurate will be the determination to the actual state of stress at a point. A long base length of measurement may miss the peak of stress. The larger the gradient of stresses, the shorter the base length should be. In uniform states of stress, the base length of the gage is immaterial except that the use of the longest allowable gage will increase the sensitivity and in some cases the precision of the measurement.

For mechanical strain gages, base length is the distance between the two knives or needle tips whose change in distance is related to the stress, Fig. 4. For wire electrical resistance strain gages, base length is the length of one of the loops of the wire whose change in ohmic resistance is related to stress, (see Fig. 5), and in X-rays it is the distance between atoms. In the grid method, base length is the distance between the lines of the grid, Fig. 8, and in the magnetic strain gages, it is the distance between the supports of the two movable parts, as in the sketch of Fig. 6(A).

DEFORMATION SENSITIVITY

The sensitivity of an instrument is defined as the smallest value of the measured quantity that can be read on the scale. It is the sensitivity of an instrument that measures changes in lengths.

Most strain gages magnify the change in distance. The smallest reading on the scale d divided by the multiplication of the instrument m gives the smallest deformation the instrument can read, or deformation sensitivity (DS).

$$DS = \frac{d}{m} \qquad (1)$$

In instruments using the bare eye to read the scale, d is of the order of hundredths of an inch.

Sensitivity should not be confused with reproducibility nor with accuracy. Strain gages can be made very sensitive by increasing multiplication, but friction, lost motion, inertia of parts, flexibility of parts, electronic noise, etc., become more and more influential as the magnification increases, and an extremely sensitive instrument may not be accurate.

STRAIN SENSITIVITY

When measured deformations are referred to the base length, i.e., converted to unit deformations, the sensitivity of the measuring instrument is called the strain sensitivity. Thus, the relationship between strain sensitivity and base length can be established. For example, if the base length is one inch, the deformation sensitivity and the strain sensitivity (SS) are given by the same number. If the base length is not one inch, the deformation sensitivity should be divided by the base length L to obtain the strain sensitivity:

$$SS = \frac{DS}{L} = \frac{d}{mL} \qquad (2)$$

When gradients of stresses are present, more refined strain gages are necessary. The mechanical strain gage made by Huggenberger has a scale on which it is possible to read 0.01 in. The multiplication of the

instrument, however, is about 1200; thus, this minimum possible scale reading corresponds to about 0.000008 in. of measured deformation. This is the deformation sensitivity of this strain gage. The distance between the knives of the instrument can be 0.5, 1.0 in., or longer. On a base length of 0.5 in., the strain sensitivity of the instrument is 0.000016, and on a 10-in. base length, it is 0.0000008.

Table I gives the values of the strain sensitivity of several common strain gages for several base lengths. In bonded wire electrical resistance strain gages, the strain sensitivity is sometimes kept constant for different base lengths, because the total length of the wire (and its ohmic resistance) is kept constant by increasing the number of loops as the base length decreases. The common instruments of this type, with conventional electronic magnification, have a strain sensitivity of about 0.000005.

When failure is used as index of stresses (for instance, in brittle coatings), strain sensitivity is defined as the minimum strain required to crack the material. In this case, the term "strain sensitivity" has a different meaning.

REPRODUCIBILITY

The exact value of a quantity is well defined when theoretical tools are used. In that sense, the stress concentration produced by a circular hole in an infinite plate under a uniform loading is three. Experimentally, no measurement obtained with a sensitive enough instrument reproduces itself when repeated a large enough number of times. The repetition of the measurement, however, allows estimates of the true value of the quantity, and of the error in the determination.

Under certain conditions of constant temperature, humidity, rate of loading, etc., the measure of some of the physical properties used in stress analysis, like birefringence or ohmic resistance, reproduce to very close values. The measure of other properties, such as the load necessary to fracture a material, reproduce less closely.

PRECISION OF MEASUREMENTS

The most probable value of a quantity to be experimentally determined is the arithmetic mean of many measurements taken of that quantity. As the number of measurements increases, the arithmetic mean value approaches the true value. The differences between this true value and the values of individual measurements are called deviations.

The degree of precision of an experimental determination can be judged by the so-called "standard deviation of a single observation", which is given by the formula:

$$\sigma = \sqrt{\frac{\Sigma x^2}{n-1}} \tag{3}$$

where n is the number of measurements and x is the deviation of each individual measurement.

Another index of the precision is the "standard deviation of the mean" or "standard error of the mean" which is given by:

$$\sigma_0 = \sqrt{\frac{\Sigma x^2}{n(n-1)}} \tag{4}$$

The standard deviation of a single observation is often referred to the arithmetic mean. The ratio of the two on a percentage basis is called the coefficient of variation:

$$v = 100\frac{\sigma}{x_0} \tag{5}$$

where x_0 is the arithmetic mean.

The smaller the deviations from the mean and the larger the number of the measurements, the smaller will be the coefficient of the variation of a determination, and the higher the degree of precision.

The idea of precision therefore is related to the reproducibility of the measurement of the physical quantity. For a determination of the degree of precision of experimental stress analysis, the measurements should be repeated several times and the results evaluated statistically, using some indexes such as those defined herein.

ACCURACY

Accuracy of experimental stress analysis determinations often means the same as their degree of precision, and can be measured percentagewise by the coefficient of variation, Eq (5).

Accuracy, however, goes beyond the concept of precision. An instrument may reproduce readings with a high degree of precision, and have a systematic error, such as the effect on a wire resistance strain gage produced by a change in temperature which is not balanced by a dummy gage, or the change in the magnification of a mechanical strain gage, due to the wearing of the knives.

As another example, in experimental stress analysis, it is a common procedure to study stress distributions by use of models. A measurement can be very precise in the model, and yet not be very accurate in respect to the prototype if the model is not built or loaded in correct similitude with the prototype.

RANGE

Range is another important concept that should be considered before the selection of a stress analysis method is made. The range of an instrument is the maximum quantity it can measure. In general, the more sensitive the insrument, the smaller its range. Ranges of some of the common strain gages are also given in Table I.

POINT-PER-POINT AND WHOLE FIELD DETERMINATIONS

Experimental stress analysis methods have to be appraised from the point of view of the scope of the required information. Some methods give a picture of the stress distribution over a whole field of stresses. Some other methods require point-per-point determinations, and the whole picture can be obtained only after the accumulation of a large number of individual results. Mechanical, optical and electrical strain gages are in the latter category. Photoelasticity and brittle coatings are in the former.

It is possible that the results obtained from a single strain gage (mainly of the electrical type) are wrong, sometimes in a systematic way, and the detection of the error is difficult without a knowledge of the distribution of the strains in the neighborhood of the point where the gage has been applied. In whole field determinations, this difficulty is overcome.

OPERATOR'S SKILL

No experimental method gives results which are independent of the operator. Sensitivity values given in the table are only approximate and depend on the operator's skill. Systematic errors depend on the operator's skill to an even larger degree. The accuracy of electrical strain gage determinations is a function of how well the gage has been cemented to the specimen; how well the soldering of the leads has been realized; how well changes in temperature are accounted for, etc. The accuracy of a mechanical strain gage depends on how skillfully the gage has been mounted. In photoelasticity, model machining, focusing and photographing require specialized training.

Often the selection of a suitable stress analysis method for a particular problem is not based on the nature of the problem and the merits of the method only, but also on the availability and the ability of the personnel to use the method.

(continued on next page)

Table I—Characteristics of Some Strain Gages

	Deformation-Sensitivity (in.)	Multiplication	Strain Sensitivity								
			1/16″ base	1/8″ base	1/4″ base	1/2″ base	1″ base	2″ base	8″ base	10″ base	100″ base
Photoelasticity (Bakelite model in standard polariscope)	——	——	——	0.00002	0.00001	0.000005	——	——	——	——	——
Brittle Coating (Stresscoat)	——	——	——			0.0003					
Micrometer	0.0001	70	——	0.0008	0.0004	0.0002	0.0001	0.00005	0.000012	0.00001	——
Dial Gage (0.0001) (Standard Co.)	0.0001 (3)	800	——	——	——	——	0.0001	0.00005	0.000012	0.00001	0.000001
Ruler	0.01	1	——	——	——	——	0.01	0.005	0.00125	0.001	0.0001
Huggenberger (type A)	0.000008	1200	not available			0.000016	0.000008	0.000004	0.000001	Extension bars up to 40″ available	
Porter Lipp	0.00003	300	not available			——	0.00003	not available			
Scratch Gage (De Forest)	0.0001	——	not available					0.00005	nct available		
Berry	0.00002 (3)	4000	not available					0.00001	0.0000025	——	——
Whittemore	0.0001 (3)	800	not available					0.00005	——	0.00001	——
C. E. J. (Mikrokator)	0.000005	——	not available	0.00004	not available	——	——	0.000002	0.0000006	0.0000005	——
Interferometer, Lateral Extensometer (Vose)	0.000002	1	——	0.000016	0.000008	0.000004	0.000002	——	——	——	——
Tuckerman	0.000004	2500	not available		0.000016	0.000008	0.000004	0.000002	——	——	——
Preuss	0.0000015 0.000003	64,000 32,000	0.00005 (12) ——	—— 0.00002	——	——	——	——	——	——	——
Martens	0.000005	1,000 (2)	not available			——	——	0.000002	0.000001	0.0000005	——
Interferometric Polariscope (Favre)	——	——	——	——	0.000002	0.000001	——	——	——	——	——
SR4 (Baldwin indicator)	0.000005	4,000	0.000005 (12)	0.000005 (12)	0.000005 (12)	0.000005 (12)	0.000005 (12)	——	——	——	——
Unbonded Electric Wire Strain Gage (Statham G1)	0.000003	——	not available				——	0.0000015	——	——	——
Linear Variable Differential Transformer	0.00005 (10)	——	not available				0.00005	0.00002	0.000006	0.000005	——
G. E. Magnetic	0.000003	3,000	not available					0.0000015 (1)	——	——	——
Grids on Rubber	0.0001	——	——	0.008	0.0004	0.0002	0.0001	——	——	——	——
Photogrids (J. A. Miller)	0.000005	——	0.005 (14) 0.00008	0.00004	0.00002	0.00001	0.000005	——	——	——	——
Acoustic Strain Gage (Telemac)	0.000013 (8)	800 (6)	not available					0.000002 (8)	0.000005 (5)	——	——
Pneumatic (De Leiris)	0.000001	7,000 (9)	——	——	——	——	0.000001	not available			
Photoelectric (General Motors)	0.000001	30,000	0.000016	0.000008	0.000004	not available					

(1)—2¼ in. base length
(2)—Variable. Used only on tensile and compressive specimens
(3)—One-fifth of the 0.0001-in. division is readable, but in general not reliable
(4)—Typical yield strain of material
(5)—200 mm base length
(6)—141.4 mm base length
(7)—Post Yield Gage is claimed to have a range of 0.1 in.
(8)—With common microscope-micrometer. Range can be much larger using gage blocks
(9)—Models with higher magnification and shorter base lengths have also been built
(10)—Models with larger deformation sensitivity have larger ranges

Range (in.)	Whole Field Information	Point-per-Point Determinations	Dynamic Determinations	
0.010 (4)	x	——	x	
——	x	——	x	
1.0	——	x	——	MECHANICAL STRAIN GAGES
0.021	——	x	——	
——	——	x	——	
0.008 (11)	——	x	——	
0.008 (11)	——	x	——	
0.25	——	x	x	
0.004	——	x	——	
0.024	——	x	——	
0.0005	——	x	——	
unlimited in usual applications	——	x	——	OPTICAL
0.02	——	x	——	
——	——	x	——	STRAIN GAGES
——	——	x	——	
——	——	x	——	
0.01 (7)	——	x	x	ELECTRICAL STRAIN GAGES
0.003	——	x	x	
0.005 – 1.0	——	x	x	
0.01	——	x	x	
0.4 (8)	x	——	——	GRIDS
0.4 (8)	x	——	——	
0.013 (6) 0.04 (5)	——	x	x	
——	——	x	——	
——	——	x	——	

(11)—With resetting
(12)—Strain Sensitivity does not vary with base length since the total length of the gage wires is the same for the different gage lengths
(13)—0.028 in. base length
(14)—0.01 in. base length

THE FIRST STEP in the analysis of complex stress analysis problems should be a survey of the literature. The solutions to many problems are available in technical articles, papers, reports and reference books. These sources may list the required solution, or, at least give a first approximation that will minimize the amount of work to be done.

Among the most important sources of information on problems already solved is Neuber's book [1] on stress concentration. The solutions presented by Neuber are approximate, but their accuracy is more than adequate for most design applications. Other important books are, those by Roark [2], Peterson [3], Heywood [4], and Lipson, Noll and Clock [5].

In general, the second step is a theoretical analysis of the problem. It is often impossible to make a rigorous theoretical analysis of an intricate machine component or structural element because only a few three-dimensional elasticity solutions are available. However, simplifications of complicated problems are often possible, and their solutions may be obtainable with the available time and money and with available personnel. These simplifications require good visualization of the physical phenomena and trained judgment on the part of the analyst.

Where a theoretical solution is impossible, too expensive, or based upon assumptions that do not represent the problem within a satisfactory degree of accuracy, an experimental stress analysis should be conducted. Often, however, the decision may be made to use experimental techniques for the sole purpose of checking theoretical results.

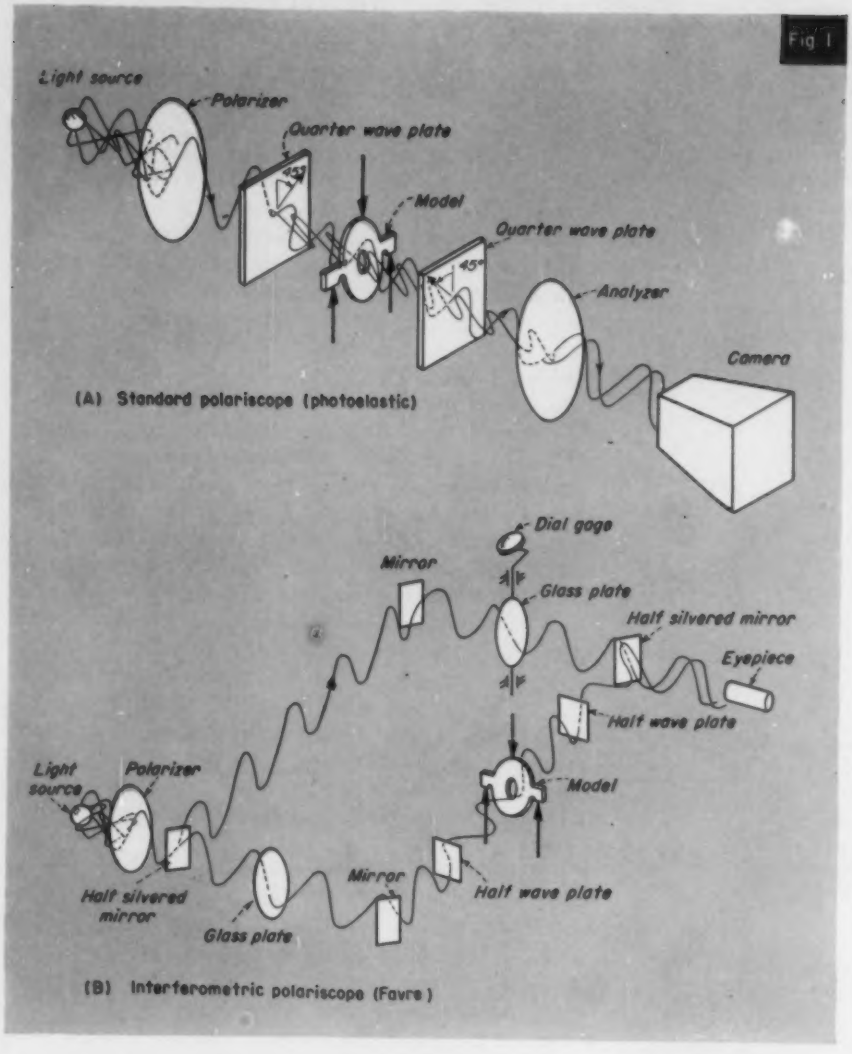
Having decided that experimental methods are necessary, the analyst then faces the relatively critical problem of determining which of the many available techniques is best suited to the application. There are no hard and fast rules; the criteria which govern such selection problems can be divided into three categories: (1) the characteristics of the problem; (2) the characteristics of the experimental techniques and the equipment associated with them; and (3) the experience and background of the analysts.

With these selection factors in mind most of the experimental techniques in use today will be discussed. The results of this discussion are summarized in Table I; the fundamental concepts used as bases for comparing and evaluating the techniques both in the table and in the discussion are defined and explained on pages 182-183.

PHOTOELASTICITY. This is probably the most precise of all methods. Also, it is among the most sensitive. In many instances where the strain gradient perpendicular to the surface is negligible, the base length can be considered to be zero. Accuracy is influenced by: (1) operators' skill; (2) model similitude; and (3) loading simplifications.

Two-dimensional as well as three-dimensional photoelasticity requires models. Model similitude is relatively simple in two dimensions, but is complicated in three dimensions because modulus of elasticity, density, cross sectional area and moments of inertia will differ between model and prototype. Often, simplifications must be introduced to make the model feasible.

Freezing techniques which are commonly used for both two and three-dimensional problems inherently have



an important limitation in that the geometry of the model is changed appreciably by the loading. The results will be applicable to the problem only when this change in shape does not influence the stress distribution appreciably.

The conventional polariscope, Fig. 1(A) using several combinations of lenses, is a delicate and expensive instrument. A sturdy and inexpensive polariscope can be built without lenses, using diffused light. The precision of the determinations is, in many cases, as high or higher than that of conventional designs. When high gradients of stress are present and a high light intensity is required for point-per-point compensation, the conventional polariscope still has advantages.

Polariscopes using the Mach-Zehnder type of interferometer, such as that developed by Favre, Fig. 1(B), are more expensive and more difficult to operate than are conventional types. They do not give whole-field information as do the conventional ones, but they separate the principal stresses in a simple manner without requiring additional tests.

BRITTLE COATINGS. Brittle coating determinations, Fig. 3, are, in general, less precise and less sensitive than photoelastic determinations, They have an important advantage, however, in not requiring models or the precise knowledge of the loading conditions. They can be used for static and dynamic problems as well, and like conventional photoelasticity, they give an overall picture of the stress distribution.

The accuracy of brittle coating tests is influenced by: (a) operator's skill; (b) control of temperature; (c) possibility of averaging results; (d) static or dynamic nature of the problem; (e) coating number, and (f) knowledge of biaxility of stresses.

Not all coating numbers reproduce their failure strain to the same degree of precision. The knowledge of the static strain sensitivity of coatings is much more advanced than the knowledge of the dynamic strain sensitivity.

One of the most important uses of brittle coatings is in the redesign of a component to save material. Since this requires an accurate analysis of understressed zones, coating sensibility is of the utmost importance. One method of increasing sensitivity is by heat-treating the coating during the curing.

A comprehensive discussion of variables that influence the accuracy of coating determinations is presented in "Study of Some Properties of Stresscoat," Society for Experimental Stress Analysis, Fall, 1950. Some new developments in the study of the effect of the strain gradient perpendicular to the crack on the failure of the coating were discussed in *Product Engineering*, Jan., 1953, pp. 136-137.

MECHANICAL STRAIN GAGES. There are mechanical strain gages of many different types, each of them having its particular characteristics. Most of them are especially useful for long static tests since they are relatively insensitive to changes in temperature and humidity. The Huggenberger gages, Fig. 4(A), are extremely sensitive but their base length, cannot be smaller than 0.5 inch. Thus, they are primarily useful for determining strains at one predetermined point, in one direction. Installation requires experience and the penetration of the movable knife, or its wearing off, must be watched carefully because any change in the original length will be multiplied by 1,200 in its effect on the final reading. The gage can be used almost indefinitely.

Porter Lipp's gages, Fig. 4(B), are easier to handle but their sensitivity is poor, and their base length too large for most strain analyses. Neither they nor the Huggenberger gages can be used dynamically.

The Mikro-kator (C.E.J.), Fig. 4(C), strain gage has the smallest error due to lag movements, friction, etc., of all mechanical gages. It is precise and sensitive, but somewhat heavier and bulkier than Huggenberger's. It has been used mainly to determine stress-strain curves.

Several mechanical strain gages have been built using dial indicators as the measuring device, with or without previous multiplication of the deformation. The Whittemore gage, Fig. 4(D), uses only the dial gage multiplication. The Berry strain gage is one of the most popular, Fig. 4(E). It multiplies the deformation five times before transmitting the movement to the dial gage. Berry gages are used primarily on large structures such as reinforced concrete bridges and are quite sensitive on a 2 in. base. In the most common application, they are not very precise, since they are removed after each reading and errors are introduced in each replacement.

The de Forest scratch gage, Fig. 4(F), can be used in dynamic applications. Its sensitivity of 0.00005 is sufficient in many cases. It does not require leads and elaborate electronic devices as do the electric strain gages, and it seems that it should be more popular than it actually is. Unfortunately, its base length cannot be brought below the 2 in. limit, and there is no way of determining the time scale in the strain-time curve recorded by the gage.

OPTICAL STRAIN GAGES. The Tuckerman gage, Fig. 4(G), is the optical strain gage most commonly used in the United States. Its deformation sensitivity is very good (about 0.000004 in.) and it can be used on a 0.25 in. base length. It is very stable and influenced little by temperature and moisture changes. Its most common application is in the determination of stress-strain curves. It has the advantage over the Huggenberger gage of a larger range (0.02 in. instead of 0.008 in.), besides being more sensitive. As in all optical strain gages, vibrations affecting the specimen appreciably influence the results and decrease the accuracy.

At the beginning of this century, Preuss in Germany developed a strain gage with a 64,000 multiplication, and a base length as short as 0.028 in., Fig. 4(H), Lehr built a similar instrument years later. Few people other than the inventors themselves ever used these strain gages, which are not commercially available. Published results of test information show high accuracy.

A sensitive gage was built by Martens, Fig. (4)I, using one mirror attached to the movable knife. It can be used only for stress-strain curve determinations, and requires particular skill in setting up. It is rarely used today.

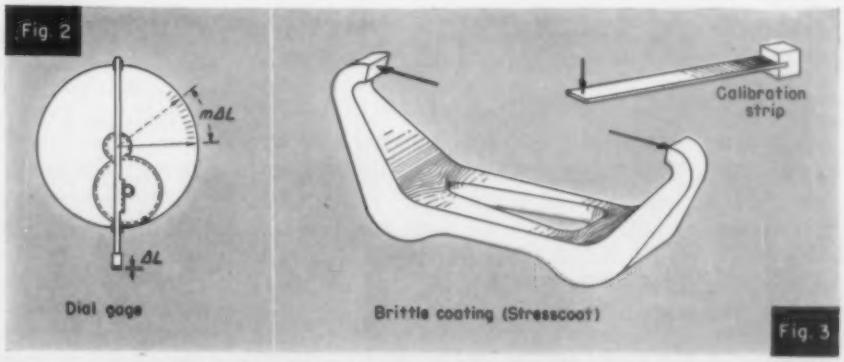
Interferometry has been used for the whole field determination of isopachics (loci of points of equal sum of principal stresses). The procedure is so delicate and expensive that it is seldom applied. The interferometric lateral extensometer developed by Vose, Fig. 4(J), on the other hand, is very sensitive and often used when the sum of the principal stresses is sought at individual points. It is influenced by vibrations, however, and requires great skill on the part of the operator. Temperature and moisture changes do not affect it appreciably.

BONDED WIRE ELECTRICAL RESISTANCE STRAIN GAGES. Since World War II, SR4 gages, Fig. 5, have become the most commonly used of all strain gages. They are sensitive, can be used on base lengths as small as $\frac{1}{8}$ in., and with proper amplifying equipment can record changes in strain of short duration, sometimes of the order of 20 micro-seconds. In general, accuracy is good in dynamic applications. For the measurement of strains applied for a long time, temperature and moisture may have an effect on the cement or on the wire, and the cement may also creep. They do not require a knowledge of the loading conditions, can be applied directly to machines or structures, and can record strains under the same operating conditions as will exist in service of the test part.

As in the case of mechanical and optical gages, electrical strain gages require the knowledge of the location of the critical stress to be measured, and if the direction of this strain is not known, the use of rosettes is required. The difficulties of recording increase rapidly with the number of gages used.

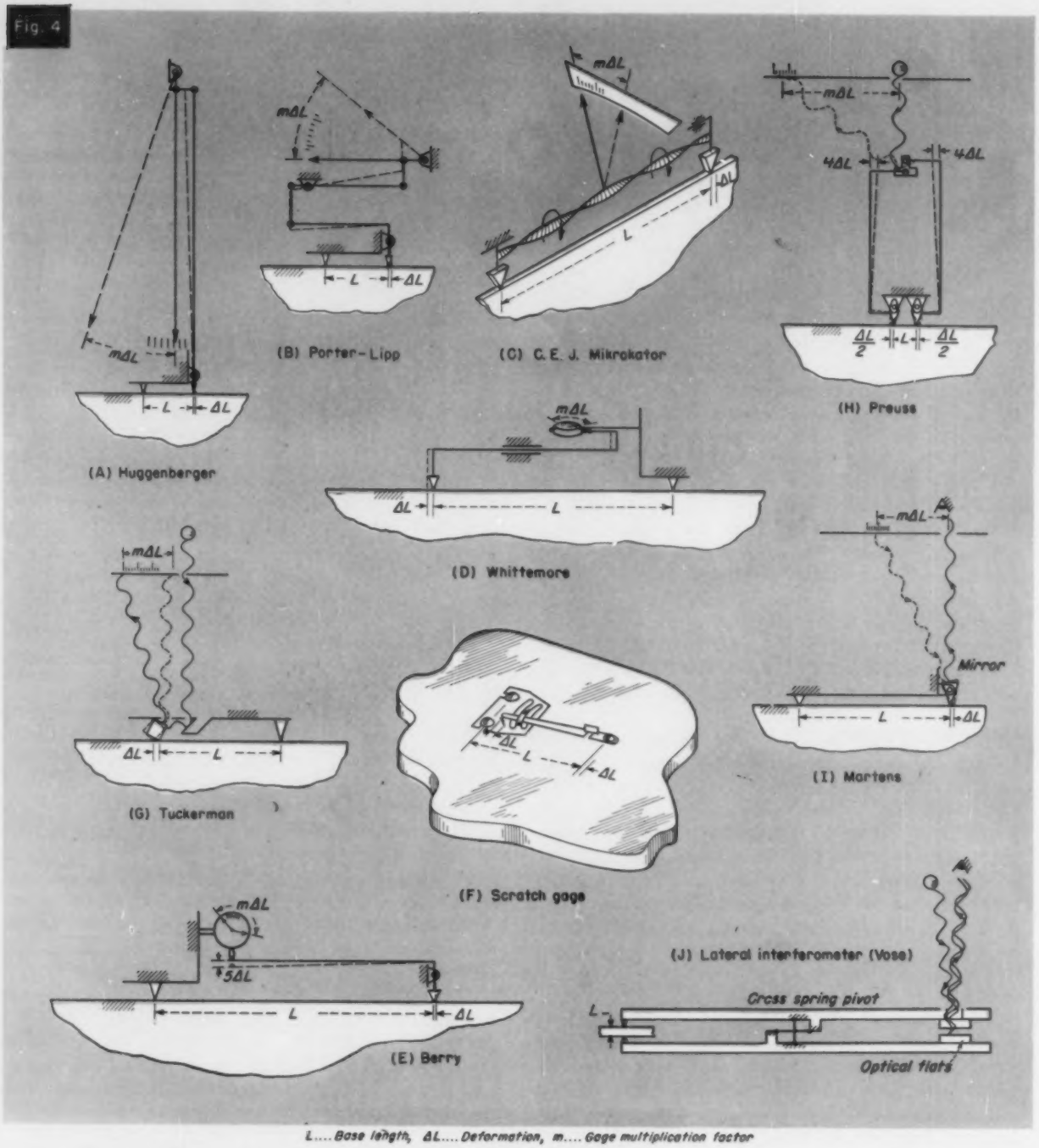
STRAIN GAGES USING MAGNETIC FIELDS. Electric strain gages of the magnetic type, such as shown in Fig. 6(A), are much less popular than the wire resistance type. They are more expensive and are available only with base lengths of 2 in. or more. They are as sensitive or more sensitive than the SR4 type, and, being influenced less by changes in moisture and temperature, they are more precise. An important drawback for the determination of bending stresses lies in the fact that the measuring part of the gage is separated from the surface of the specimen.

The same principle is used in the linear variable differential transformer, Fig. 6(B), which allows the recording of deflections. Since it provides a means of recording, it is often preferred to dial gages. This type of gage is available in several ranges (up to 1 in.) in several sensitivities (up to 0.00005). Several interesting applica-



L.... Base length, ΔL.... Deformation, m.... Gage multiplication factor

Fig. 4



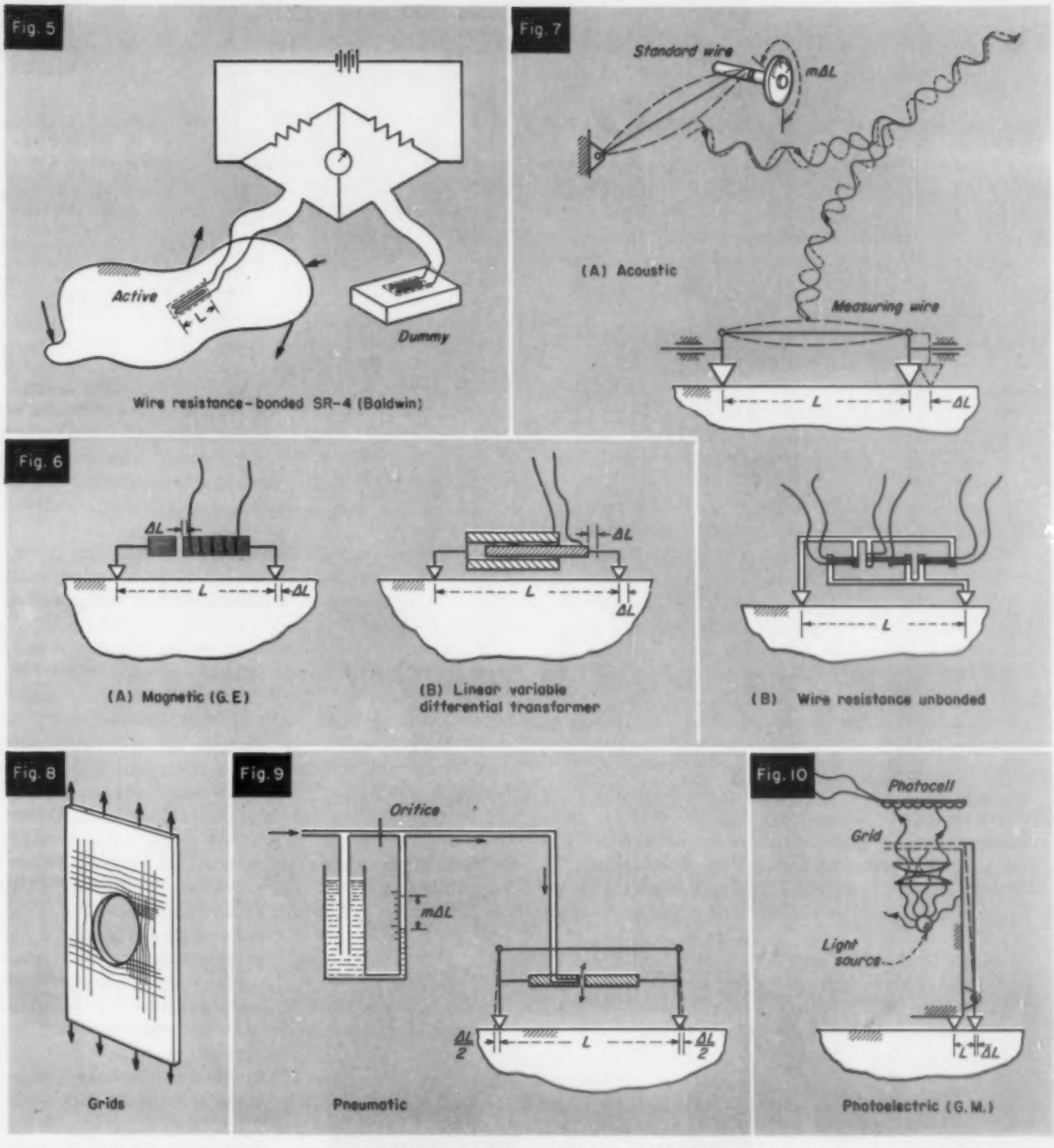
L.... Base length, ΔL.... Deformation, m.... Gage multiplication factor

tions as well as performance characteristics of the LVDT are given in *Product Engineering Annual Handbook of Product Design for 1953*, pp. I16-21.

ACOUSTIC STRAIN GAGES AND UNBONDED WIRE ELECTRIC RESISTANCE STRAIN GAGES. The field of application of acoustic and unbonded resistance gages is rather limited. To date, they have been used mainly for the determination of strains inside concrete structures, where the gages are left for long periods of time. An unbonded gage of the Carlson type is shown in Fig. 7(B), and the principle of the acoustical gage is illustrated in Fig. 7(A). Both have base lengths considerably longer than do SR4s. The unbonded wire resistance gage is used in accelerometers and pressure gages as is the bonded type (*Annual Handbook of Product Design for 1953*, pp. I22-25).

GRIDS. Grids can be applied to rubber models by drawing, printing, cementing of rubber threads, etc., Fig. 8. The deformations are read by means of microscopes or comparators. The method is seldom used, although it has several possibilities of application. The main limitation lies in the difficulty of reading deformations on curved surfaces.

Photogrids have been refined recently to a high degree



L.... Base length, ΔL.... Deformation, m.... Gage multiplication factor[1]

of precision, and are used for the measurement of plastic strains in metals. In some instances, however, they could be used for the determination of large elastic strains.

PNEUMATIC STRAIN GAGES. The changes in distance between two points can also be determined by measuring changes in air pressure. This method allows some of the largest magnification ever obtained with strain gages, up to 100,000 times. The pneumatic strain gage, Fig. 9, has been used mainly in France and Sweden for the determination of elastic constants. The deformation sensitivity is about one micro-inch; and, like most sensitive instruments, the pneumatic gage is difficult to handle.

PHOTOELECTRIC STRAIN GAGES. These gages, Fig. 10, are also very sensitive, and have been made with small base lengths, for example Table I indicates that one type has been developed with a base length of ⅛ in. They are stable, and influenced little by changes in temperature and moisture but have been used by only a few scientists in Germany and in the United States.

X-RAYS. The diffraction produced in X-rays by some metals can be used to measure the change in distance between atom, which is a consequence of stress. It applies only to elastic stresses, requires expensive equipment, experienced operators. The interpretation and accuracy of data is often

debatable when stresses in hard materials are analyzed. This is, however, the only method that allows the determination of residual stresses without cutting or drilling the specimen.

PIEZOELECTRIC STRAIN GAGES. The piezoelectric property of some crystals has been used mainly to measure pressures. In some crystals, ammonium dihydrogen phosphate for example, the electric potential produced by the change in dimensions of the crystal has been correlated with a strain. The advantage of such a gage is its high sensitivity, which can be 1000 times that of the SR4. This is also true of barium titanate.

Usually, each gage must be calibrated separately because of the lack of uniformity in response, and the relationship between the gage response and the strain is not often a simple one. For example, the ammonium dihydrogen phosphate gage does not respond under shear, and the response to compression in two perpendicular directions is not the same.

COMBINING EXPERIMENTAL TECHNIQUES

The best approach to the solution of a stress problem is often that of combining several methods. In this way, data can be checked in areas where more than one method can be applied, and supplemented where one method does not give enough information.

A typical use of this principle is the combined use of SR4 gages and brittle coatings. Brittle coatings readily give the directions of the principal stresses. Thus, only one SR4 gage is needed or two at most, instead of a rosette. Also, brittle coatings pinpoint zones of maximum stress indicating where SR4 gages should be applied. Photoelasticity may be used to determine stress concentration factors with high precision at critical points or other discontinuities identified by the brittle coatings or strain gages. Another efficient procedure is the combination of dial gages and mechanical strain gages in solving structural problems.

In most design applications, it is not necessary to know the two principal stresses individually. Usually, their difference which is proportional to the maximum shear stress and which is given directly by photoelasticity, is adequate. However, when the principal stresses must be separated, the general procedure is to combine isochromatics (lines of equal difference of principal stress) obtained by photoelasticity with (a) an auxiliary test which gives their sum, (b) isoclinics also from photoelastic tests plus an integration of the stress equilibrium equations, (c) isostatics from brittle coatings plus a similar integration or (d) a numerical solution of the Laplace equation, which gives their sum.

When the separation is required only at a few points sensitive lateral extensometers, such as the one developed by Vose, can be used to obtain the sum of the principal stresses.

When the principal stresses are to be separated over a large region, lateral extensometer determinations are too tedious. Whole field methods are then more advantageous. Among these methods, the numerical solution of the Laplace equation by iteration is very popular and gives results without much effort or special skill. This method is useful mainly when the boundaries are straight and when the gradients of the stresses are not high. When the boundaries are of complicated shape, corrections in the iteration procedure make it more cumbersome. When the gradients are high, the procedure must be repeated several times, going to a finer network after each step. This is also a lengthy operation. In many cases, graphical integration using ischromatics and isostatics will be found to be more practical. Fig 11 shows these sets of loci for the case of a hole in a plate loaded in uniaxial tension. A graphical integration, however, by its own nature, is not a very precise method and requires checks and sometimes a skillful redistribution of accumulated errors at various stages.

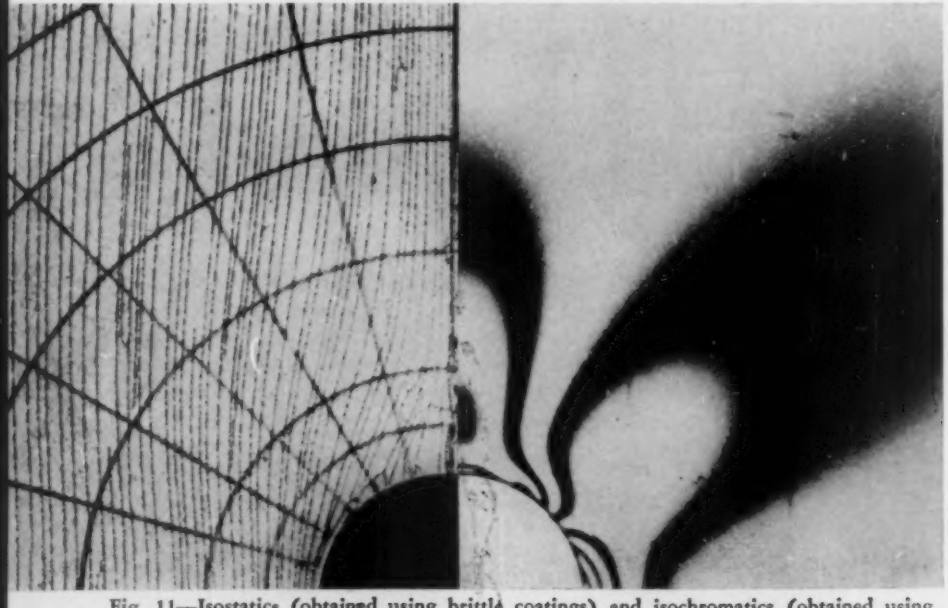


Fig. 11—Isostatics (obtained using brittle coatings) and isochromatics (obtained using photoelasticity) in a plate with a circular hole under an undimensional load.

It should be noted that the use of any of the methods of solving the Laplace equation requires a knowledge of the stresses everywhere on the boundary. It should also be noted that the methods of solving the Laplace equation allow the separation of the principal stresses, but do not

give their directions. When this information is required, isoclinics (from photoelasticity) or isostatics (from brittle coatings) should be recorded.

Another efficient procedure may be the combination of dial and mechanical strain gages in solution of structural problems.

Photoelasticity can be used to determine, with high precision, stress concentration factors as produced by discontinuities in components after field stresses have been determined by strain gages and coatings.

As previously discussed, when principal stresses are to be separated, it will be found advantageous in many cases to avoid the determination of isochnics in photoelasticity and to use brittle coatings on the test surfaces instead, to obtain isostatics.

When stresses in the interior or on inaccessible surfaces are required, the only possible method to use may be a model made from some brittle material like plaster.

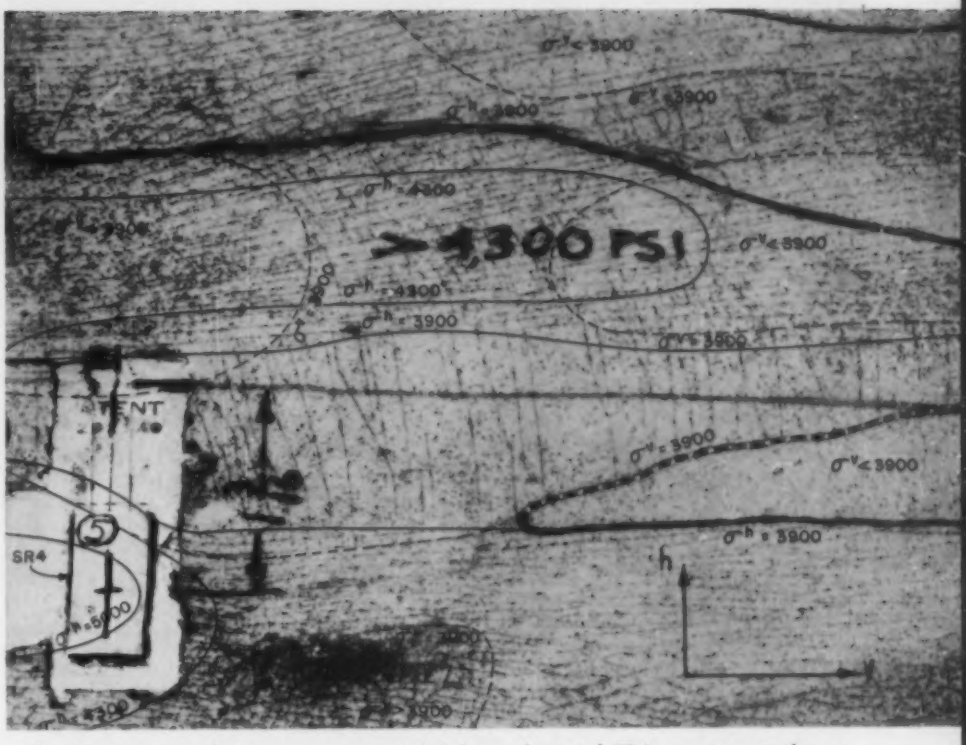


Fig. 12—Example of simultaneous use of brittle coatings and SR4's to stress analyze a thin shell loaded under impact. The thin lines are cracks in the coating and coincide with the direction of the principal stresses. They show a stress wave that had travelled in the h direction, preceding a second wave that had travelled in the v direction. Heavy lines are isoentatics along which the maximum tensile stresses are approximately equal. The value of this stress is given in psi by the figures on the isoentatics. The SR4 was placed at the point where the stress occurring in the h direction wave was a maximum as indicated by the isoentatic and by the density of cracks.

SIGNIFICANCE OF STRESS AND STRAIN MEASUREMENTS

The state of stress at a point is completely defined only when the values of the three principal stresses and their directions are known. No stress analysis method gives this information directly and at every point of the stressed body.

Also, only in a few cases is a stress analysis conducted for the sake of knowledge alone. Most of the times the objective is to design better structures or machines, and the construction of better components is governed by failure either by yielding or by fracture. Yielding and fracture are determined by some significant stresses, or strains, or combinations of stresses and strains, which are not the same for all materials, nor for all kinds of service temperatures. The problem of determining which quantities are significant is therefore very important, and requires previous knowledge of the loading conditions of the component and the material to be used. The analyst must decide whether he needs maximum tensile stresses, maximum shear stresses, or the three principal stresses, and whether this knowledge is required at a single point, everywhere in the field, or in the neighborhood of a point. Laws of failure have not been definitely established for all materials and all loading conditions.

As an example—in many instances, some degree of plastic yielding can be allowed and will, in fact, be present in some components even when the designer does not realize it. This will not necessarily produce failure in the component. It may not even be important enough to produce appreciable permanent deformations in the overall deflection of the component. In these cases, the determination of a highly localized peak stress is less important than the knowledge of the general level of stress in the neighborhood of the peak.

As noted previously the objective of the analysis often is not to avoid failure, but to save weight. In these cases, whole field methods, in particular brittle coatings, have a very definite advantage. They also present an advantage when both objectives, the saving of weight and the decreasing of the maximum stresses, are present.

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Fig. 1—Some wrought products of the aluminum base, copper-cadium alloy, which include wire, sheet, forgings, stampings, and extrusions. The Venturi forging in the center was made with a wall thickness on emergence from the die of 0.187 in., ± 0.008 inch.

Aluminum-Base Copper-Cadmium Alloys

New aluminum-base alloys can be easily worked; will stand greater reduction than most aluminum alloys; have good hot working characteristics; offer increased production rates at lower costs through less critical intermediate heat treatment.

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IN EARLY RESEARCH on aluminum-copper alloys, Fig. 1, it was found that accelerated aging could be obtained by additions of small quantities of cadmium, indium and tin. It was believed that this was caused by the lower solid solubility of these elements in aluminum at the precipitation hardening temperature which formed a larger number of centers of precipitation. Initial work was carried out with an alloy containing from 4 to 4½ per cent copper; Fig. 2 compares the age hardening in a straight 4 per cent copper alloy with alloys to which either cadmium, indium or tin were added.

Much greater hardening effect is obtained with these additions, and maximum hardness is reached in a shorter time that with the straight aluminum-copper alloy. These additions increase both the hardening rate and maximum hardness, at aging temperatures as low as 350 F, yet no significant hardening occurs at room temperatures. Typical properties of the new aluminum-copper cadmium alloy are shown in Table I.

This effect of tin had been noted in studies made at

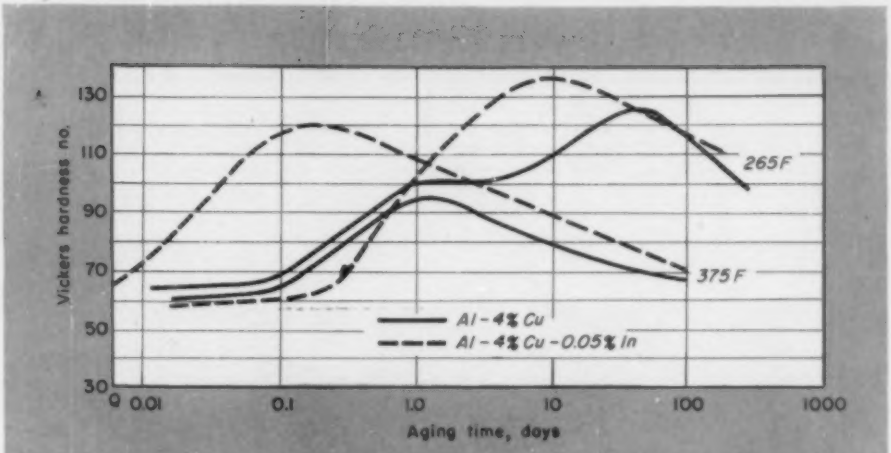

Fig. 2—Hardness curves for Aluminum—4 per cent Copper, and Aluminum —4 per cent Copper—0.05 per cent Indium alloys aged at 265 F and 375 F. It shows a greater hardening effect with the alloying elements, in a shorter time, than with a straight aluminum-copper alloy.

Table I—Typical Properties of Aluminum-Base, Copper-Cadmium Alloys

Tensile Properties	0.2% Proof Stress, psi	Ult. Tensile Strength, psi	Elongation 2 in. or $4\sqrt{A}$
(a) Fully Heat Treated, not cold worked between solution and precipitation hardening	60,000	68,000	10%
(b) Solution heat treated and held at room temperature	20,000	42,000	25%
(c) Fully heat treated, but stretched or otherwise cold worked between solution heat treating and precipitation hardening	52,000	64,000	10%

	Fully Heat Treated	Solution Heat Treated		
Impact Properties	10 ft.-lb.	37 ft.-lb.	Young's Modulus	10.3 to 10.7 $\times 10^6$ psi
Resistivity	4.9 micro ohms/cm²	5.2 micro ohms/cm²	Thermal Exp. 0–250F	24.0 $\times 10^{-6}$ per deg. F
Minimum radii for 180° bend (t = thickness)	3t	0.5t	Density	0.102 lb/in.³
			Fatigue, fully Heat Treated	22,000 psi 50×10^6 reversals

the Aluminum Company of America, but additions of tin or indium have the disadvantage of requiring only very small amounts (about 0.05 per cent) to produce maximum hardness. Any excess tends to make the alloy hot short, since it tends to segregate at grain boundaries where it forms a weak, low-melting film. Both tin and indium also combine with small quantities of magnesium to form intermetallic compounds, which interfere with age hardening. Since virgin aluminum commonly contains traces of magnesium of the order of 0.02 per cent, it is difficult to control the tin content to obtain optimum hardening without introducing hot shortness.

With cadmium, it takes larger amounts of the order of 0.1 per cent to produce maximum hardening, and the higher melting point of cadmium reduces the degree of hot shortness with an excess of cadmium. Most important, however, cadmium does not combine with magnesium to form an intermetallic compound, and it is therefore easier to control the composition of the alloy.

Higher copper content produces higher maximum properties but no marked advantage appeared when the copper content was increased above about 5½ per cent. The virtual absence of magnesium in these alloys increases the temperature at which melting begins, and allows using a higher solution heat treatment temperature as compared with 24S alloy. This, in turn, allows a larger proportion of copper to go into solution. However, the silicon content must be limited with the higher copper alloys to prevent incipient melting when higher solution heat-treatment temperatures are used.

Maximum physical properties in these materials were obtained from forgings. With sheet or extrusions the straightening operation ordinarily used between solution heat treatment and precipitation hardening slightly reduced the maximum properties obtainable. The first tests of these alloys on a production scale showed that: (1) they had excellent hot working characteristics; (2) using similar shaped parts, they could be extruded at approximately three times the rate of 24S alloy; and (3) hot rolling the alloys gave sheet with much less tendency to edge cracking.

RECOMMENDED COMPOSITION. The recommended range of composition in per cent is as follows:—

Cu 4.8–5.4	Mg < 0.10 (aim at less than 0.02)
Cd 0.1–0.15	Sn < 0.005
Si < 0.25	Pb < 0.05
Fe < 0.3	Zn < 0.05
Mn 0.3–0.8 (aim at 0.5)	Ni < 0.05
Ti 0.2 (aim at 0.1–0.15)	Cr < 0.02

Copper increases the ultimate tensile strength of the

alloys up to the solid solubility limit at the solution heat treatment temperature. But any increase in copper content above about 5½ per cent is not justified, since it is accompanied by an increase in density. Cadmium content should not exceed the solid solubility at the solution heat treatment temperature, as contents much in excess of this tend to cause hot shortness. For example, an alloy containing 0.25 per cent cadmium showed a tendency to crack in hot working. Cadmium contents much below 0.1 per cent are insufficient to produce the maximum increase in precipitation hardening. Magnesium in small quantities does not affect the heat-treated properties, but if more than 0.1 per cent, there is some tendency to room temperature age hardening. Unless deliberate additions of magnesium are made, however, there is little difficulty in keeping the magnesium content down to a maximum of 0.02 per cent.

Influence of manganese has not yet been fully investigated, but alloys with a range of 0.3 to 0.8 per cent are satisfactory. Copper plus silicon should be limited to keep incipient melting below 1015 F. The limiting silicon content is related to the copper content, so that silicon should not exceed 2.4 per cent minus 0.4 times the copper content.

Table II—Properties Obtained on Test Pieces Shown in Fig. 1

	0.1% Proof Stress, psi	Ultimate Tensile Strength, psi	Elongation, percent
Longitudinal	65,000	73,000	9
Transverse	62,000	71,000	6

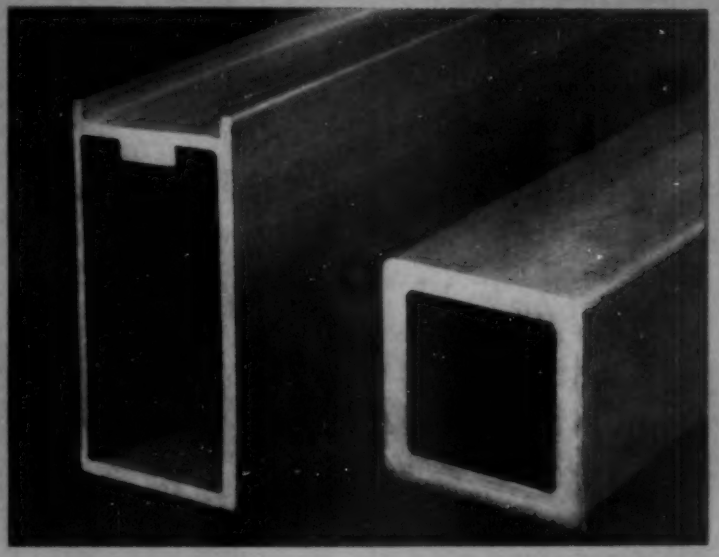

Fig. 3—Sections of bridge die extrusions using the new aluminum base alloy. In the case of the thinner walled section, the welds are in the centers of the side walls, and in the other sections the welds are at the corners.

CASTING. Loss of cadmium by volatilization must be avoided in melting. This can be done by adding the cadmium shortly before casting, and the temperature of the melt should not exceed 1350 F after the cadmium additions have been made.

There is no difficulty in casting by any conventions means, including continuous casting. Most of the applications of these materials are in the wrought form, and only a limited amount of experimental work has been carried out on castings. But it has been shown that cadmium additions to the 4½ per cent copper casting alloy, and to the aluminum-silicon-copper alloys accelerate their response to precipitation hardening. In the fully heat-treated condition, higher proof and ultimate strength are attainable than in the cadmium-free materials. For example, heat-treated sand castings in a 4.25 per cent copper alloy can be specified to have a 0.2 per cent proof stress of not less than 45,000 psi., and an ultimate tensile strength of not less than 56,000 psi.

FORGING. Aluminum-copper-cadmium alloys are easier to forge than any of the other high-strength aluminum alloys. Not only can the material withstand greater reduction, but the range of satisfactory hot forging extends from about 975F down to approximately 400F. The only limitation is that cold coining, which is carried out between solution heat treatment and precipitation hardening, causes a slight drop in properties. This is discussed later on under the heading of, "Heat Treatment: Influence of Cold Working in the Solution Heat Treated Condition".

The Venturi forging, shown in the center of Fig. 1, was made with a wall thickness on emergence from the die of 0.187 in. ±0.008 in. The properties of the flat test pieces on the side walls and small cylindrical test pieces from the base are shown in Table II.

The components of this Venturi forging were stamped from 3 in. dia. dummies in only two operations without intermediate heating, using a two hundred pound hammer.

EXTRUSIONS. Extrusions have been made with wall thicknesses varying from 0.050 in. to 4 in., and extrusion speeds have varied from 25 to 40 feet per minute. In all cases the speeds were two to three times as great as for

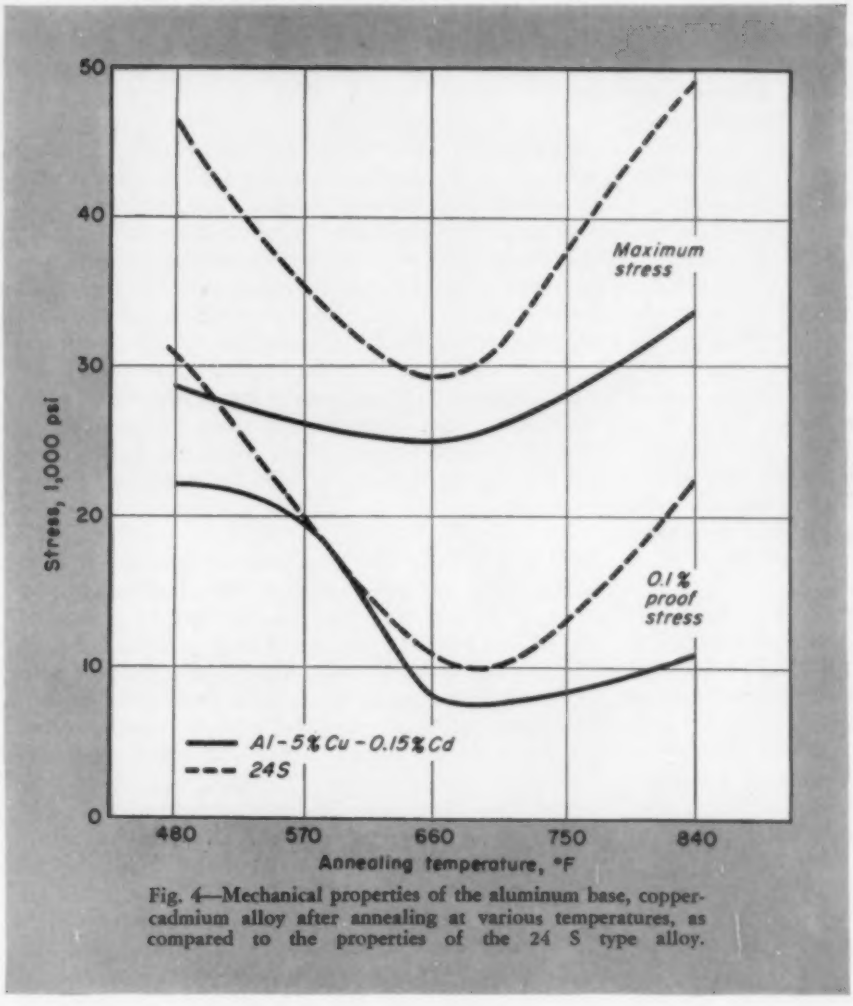

Fig. 4—Mechanical properties of the aluminum base, copper-cadmium alloy after annealing at various temperatures, as compared to the properties of the 24 S type alloy.

the 24S material extruded under the same conditions. Recommended extrusion conditions are: billets soaking 840F to 875F for six to eight hours; extrusion temperature 805F to 840F for the billet, and 715F to 735F for the container. The slight drop in properties obtained on the straightening of extrusions between solution heat treatment and precipitation hardening is discussed under, "Heat Treatment" below.

More remarkable is the fact that successful extrusion can be made using a bridge die. Fig. 3 shows hollow sections made using 4-part dies.

ROLLING AND TUBE MAKING. In tube making and sheet rolling, an advantage is that the annealing temperature necessary for intermediate softening is less critical than is the case with the 24S alloy. Fig. 4 shows the properties of the 24S alloy compared with the aluminum-copper-cadmium alloy after annealing at temperatures from 480-840F. If maximum resistance to deformation is required, there is little difference in the 0.1 per cent proof stress figures for the aluminum-copper-cadmium alloy on annealing in the temperature range 660-840F. For example, after annealing at 840F, the proof stress is only 5 tons/sq. inch, whereas 24S material will have a proof stress of 10 tons/sq. inch. The reason for this is because the aluminum-copper-cadmium alloy does not harden at room temperature.

Annealing between cold working operations can normally be carried out by short-time annealing at high temperatures; for example, by flash annealing. With 24S alloy, it is usually necessary to anneal in a comparatively narrow temperature range, and to follow this by slow cooling. If the annealing conditions appropriate to the 24S type alloy are used, the aluminum-copper-cadmium alloy shows no marked advantage over the 24S alloy. The advantage is that intermediate annealing can be accelerated and carried out in a less critical temperature range, thus increasing production rates. The aluminum-copper-cadmium alloys show an advantage when they are cold worked in the solution treated or 'as extruded' condition.

In sheet manufacture, the higher solution heat treatment temperature that can be used for the aluminum-copper-cadmium alloys, as compared with the 24S type, gives a higher rate of copper diffusion into the cladding, which may result in lowering of corrosion resistance in the thinner gages. This can be minimized by adjusting the intermediate heat treatment so that the final solution heat treatment time can be reduced to a minimum.

PRESSING AND DEEP DRAWING. Tests have been made on samples of sheet, which show that the aluminum-copper-cadmium alloys in the solution heat treated conditions still have excellent formability, even after twelve months at room temperature. The formability was checked by tensile tests and free cone and drop hammer tests. The 0.036 in. thick sheet could be bent flat, and had forming characteristics similar to that of fully annealed or freshly solution treated 24S alloy.

WELDING. The welding characteristics of the alloys are equal to those of other high strength aluminum alloys. Tests show that after re-heat-treatment, argon arc welded sheet has properties equal to those of the unwelded parent sheet.

MACHINING. The alloys have excellent machining characteristics, both in the solution heat treated and fully heat treated condition. This is useful in cases where high

strength components need complicated machining, since there is evidence that the machining operation can introduce internal stresses into high strength alloys. The aluminum-copper-cadmium alloys can be solution heat treated and machined at any convenient time thereafter. In this condition the alloys are so ductile that the level of internal stress is limited. Increasing the final precipitation hardening heat treatment reduces the small amount of internal stress that may have been introduced in the machining process.

HEAT TREATMENT. (Solution heat treatment). As has been explained, the high strength in the fully heat treated condition is obtained by taking as much copper as possible into solid solution. The effective solidus temperature, that is, where incipient melting begins, is in the region of 1015F in the aluminum-copper-cadmium alloys, and is about 75 to 85F higher than that of the 24S alloys. Therefore, the solution heat treatment temperature used in practice, can be higher by an equivalent amount, and solution heat treatment in the temperature range of 985F ± 5F is recommended.

The time necessary at the solution heat treatment temperature will vary with the amount of segregation, and will be much longer in the cast billets than in wrought products. A solution heat treatment time of not less than eight hours is necessary for billets, but with sheet or wire, this time can be cut to around 15 minutes. There is no loss of cadmium during the heat treatment. Sections of over 4 in. show a mass effect on heat treatment, and it is impossible to quench these rapidly enough to produce the maximum properties. The artificial aging, or precipitation hardening, is best carried out in the temperature range of 330-365F. The highest properties are obtained by using lower temperatures for relatively long times.

The recommended times and temperatures of heat treatment are:—

365F	4–8 hours
356F	6–12 "
347F	8–16 "
338F	10–24 "
330F	16 hours minimum

INFLUENCE OF COLD WORK IN THE SOLUTION HEAT TREATED CONDITION. In all aluminum alloys other than the aluminum-copper alloys containing cadmium, indium, or tin, cold working between solution heat treatment and precipitation hardening increases the mechanical properties. However, additions of cadmium, indium, or tin, to the aluminum-copper alloy cause a unique response to cold working. About 5 to 10 per cent of cold work between solution heat treatment and artificial aging reduces the effect of the added element, and causes the alloys to behave similarly to straight aluminum-copper alloys. This effect can be minimized by reducing the amount of straightening or levelling after solution treatment, or by postponing such treatment until after the final heat treatment.

It must be remembered, that in the fully heat-treated condition the ductility is relatively low (of the order of 10 per cent), and working after full heat treatment will raise the ultimate tensile strength at the expense of ductility. The most effective method of overcoming cold working is to pre-age for a sufficient time to get about half the increase in hardening attainable on full heat treatment, then follow this by a final precipitation hardening.

CORROSION AND STRESS CORROSION. Corrosion resistance of the aluminum-copper-cadmium alloys is similar to other aluminum-copper alloys. The effect of alloying with copper has always been to reduce the overall corrosion resistance of aluminum, so that it is necessary to give some protection when these alloys are exposed to abnormally corrosive atmospheres. The aluminum-copper-cadmium alloys are not appreciably susceptible to stress corrosion or intercrystalline attack in the fully heat treated condition. The cadmium additions appear to greatly improve the resistance to intercrystalline and stress corrosion of the straight aluminum-copper alloy. However, if the alloys are not fully aged, there is some susceptibility to stress corrosion.

APPLICATIONS. The aluminum-copper-cadmium series of alloys have mechanical properties which approach those of the 24S alloys, and they can therefore be used in all applications where the aluminum-copper-magnesium alloys have previously been used. They retain ductility after solution heat treatment, which makes them useful in many fabricated applications, provided a small decrease in final properties can be tolerated. It is also possible that the alloys will find applications in structures, and wherever a moderately high strength alloy is required where ease of fabrication is an important point. They can be used to produce difficult extruded sections; and, provided they are adequately protected against abnormal corrosion, they can be used for structural work. They are particularly useful in parts to be machined, and it is anticipated that they will be used for moderately high strength aluminum alloy nuts and bolts; and in sheet form for motor-car bodies, where their excellent deep drawing and pressing characteristics in the solution heat treated condition will prove particularly useful.

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WHAT HAPPENED TO THE COMET in the Elba disaster is shown here. Initial failure occurred around the rear ADF window, located on the top of the fuselage. This immediately ripped out a section of the fuselage running from the rear ADF window to the forward window, and down to the cabin window line (dotted line). Immediately, explosive decompression of the cabin took place, disgorging all the passengers, (within ⅓ sec.) and simultaneously ripping off the entire top of the central cabin area.

Comet Crash Inquiry Aids Future Aircraft Design

The recent exhaustive inquiry into the causes of the British Comet jet airliner crashes promises to affect greatly the design requirements and testing methods of modern pressurized aircraft in England, and to some extent in the U. S. Of more interest may be some information on the characteristics of high-strength, light weight alloys in complex structures under cyclical loading, such as a plane during take-off, climb, and landing. Actually, U. S. aircraft companies have been building pressurized planes for years, and have had little trouble with them —certainly not like the two Comet disasters at Naples and Elba.

Some of the lessons British airframe builders have learned from these tests are:

- Permanent alteration of structural characteristics as a result of plastic flow during high-load static testing.
- The unreliability of the results obtained from fatigue testing a structure that has first been subjected to severe static loads.
- Failure of pressure cabins can be caused by a small crack, and can be disasterous.
- The need for calculating maximum stress at a point rather than the mean or average stress over an area in airframe design.
- Specific procedures for determining minimum safe fatigue life, and for predetermining component replacement schedules rather than relying on operational experience alone.

All in all, the Royal Aircraft Establishment (RAE) headed by Sir Arnold Hull, has shown that a number of

practices long accepted as axiomatic to the design and testing of airframes are no longer reliable when applied to an airliner flying at 40,000 ft. at 500 mph and up, and which must contain a differential internal pressure of over eight pounds per sq. inch. It is understood that the British Air Registration Board is changing their pre-certification requirements, affecting airframe design immediately. Thus, designers will be forced to keep weight down, and pay load up; also it will mean costlier aircraft, and smaller commercial operating margins.

Other questions raised, but not fully answered, are: the number, positioning, and spacing of rivets; the effects of changing differential temperatures on glued metal joints; methods of bevelling for countersunk rivets and bolts in a thin skin; and the shape of cutouts—windows, doors, etc.—in a pressurized fuselage.

The Comet I was made by the de Havilland Aircraft Co., Ltd., and was the first jetliner in commercial service. At the time (1946-1949), it was designed and tested to greatly exceed the minimum requirements of both the ARB and CAA. But actually, de Havilland's stress calculations gave incorrect results; their static and fatigue tests were invalid; and the plane was built accordingly. The result was, according to the recent tests, that the plane had a minimum safe fatigue life of little more than 1,000 hours. The company based its work primarily on calculations and empirical tests, using strain gages only to warn of possible failure during static tests, and not to check the calculations. RAE conversely, relied mostly on strain gages for checking its calculations.

In preparation for the water tank test, the 250,000 gallon tank was built around the fuselage, with the wings protruding through specially fitted holes, adequately sealed to prevent leakage. The seal is just outboard of the engine nacelles. Under each wing are placed four hydraulic jacks to put flight and gust loads on the wings. The fuselage is lead ballasted to simulate an actual fully loaded liner. Gust loads were fed into the wing jacks according to a pattern derived from 2,000 hours of accelerometer recordings taken on the Comets in actual flight. As 60 per cent of the fatigue damage to the Comets wings occurred below 8,000 ft., the gusts fed into the wings were based on the conditions obtained at this level. Pressure, in the form of water at 8¼ psi was pumped into the fuselage to simulate the climb to 40,000 feet. But on the basis of the wing tests alone, the Comet was in as much danger from wing fatigue as from pressure cabin fatigue.

CRACKS IN THE BOTTOM SKIN of the port wing stand out after the removal of a rear spar gusset plate during the recent tests. This test model used did not have the modifications included on Comets after the Elba crash. However, these modifications were just concerned with wing strengthening, and had nothing to do with strengthening of the fuselage against fatigue failure.

Some effects which could not be reproduced for the test on the pressurized cabin were: fluctuation of cabin pressure during actual flight; vibration stresses caused by the engines, which are superimposed on the pressure loads; and additional stress produced in the cabin shell by contraction through low temperature at high altitude. None were assessed accurately to determine its effect on fatigue life, but all were considered detrimental. The conclusion was, then, that the life under actual operating conditions would be less than the test results indicated.

As a result of the Air Registrations Board's (ARB) various tests, new requirements have been set up which must be met before any pressurized aircraft can be certified in Britain for commercial passenger carrying operations. These conditions are:

1. Tests will be required on two separate airframes without equipment; one for the water tank fatigue test, and the other for static tests. The water tank tests must include simultaneous flight-gust and pressurization loadings, probably to 15,000 pressurization reversals, with equivalent one "g" flight and 10 ft./sec. gust loads. Two airframes are needed, because once one has been subjected to preloading in the form of excessive static loads, it cannot give accurate results in the fatigue test, and vice versa. In addition, components, probably equivalent to another complete airframe, will have to be supplied for "to destruction" testing to determine average fatigue life.

2. Flying tests to include extensive flying over proposed routes with a fully instrumented aircraft.

3. Additions to the ARB of one or more members picked for "their eminence in the scientific field." The present arrangement consists chiefly of representatives from the various British aircraft companies.

4. An expanded research program into the whole problem of fatigue in high grade light alloy metals.

ARB does not expect that the water tank fatigue tests to destruction will be a requirement indefinitely. When the results of a series of physical tests can be put into a set of rules relating fatigue life to structure design, pre-acceptance testing may be modified.

RCA Charged Monopolistic

The Radio Corporation of America, the biggest seller of radio and television products, has been hit with a monopoly suit by the government charging that "since 1932 RCA has followed a deliberate policy of monopolizing radio-TV research, patents and patent rights in the field, and the issuance and exchange of radio-TV licenses to other manufacturers."

Through its subsidiary, the National Broadcasting Co., RCA broadcasts radio and TV programs to more than 180 radio and 63 television stations. RCA also owns or controls the rights to about 10,000 patents in the radio-TV field, from which it collects an annual income in royalties of over $20-million.

The government's objective is to break the strangle hold it claims that RCA holds on competitors, but how far it will go—providing a court finds RCA guilty—is anybody's guess. The government could go so far as to require RCA to dedicate to the public many of its patents. This was done last year with General Electric Corp., who was found guilty of monopolizing the incandescent lamp business.

The government's complaint against RCA lists as co-conspirators: General Electric; AT&T; and its subsidiaries Western Electric Co., Inc., and Bell Telephone Laboratories; and Westinghouse Electric Corp. These are the same companies involved in a case brought up in 1930, charging a conspiracy to monopolize the manufacture of radios and the sending of messages by wire and radio.

The big target of the monopoly suit is RCA's "package licensing" policy. The government charges that almost all of the licenses issued to U. S. manufacturers of radio and TV equipment have been licensed under the restrictive package system. RCA classifies its patent licenses into four groups: radio and TV receivers; commercial radio apparatus; receiving tubes; and transmitting and power tubes. Any manufacturer in any of the four groups has rights to any of the 10,000 patents that are applicable to the product he is making.

In order to make a radio or TV receiver using any RCA patent, for example, a manufacturer has to accept licenses for all 10,000, even though he wants only one or two. However, he may use them only to make radio or TV receivers. When the manufacturer sells his set, he must pay RCA a royalty, which runs from 1¼ to 4 per cent on the manufacturer's selling price of the completed receiver.

The government also charges that anyone who attempts to invent around RCA never really knows which RCA patent is involved. Although some 250 infringement suits have been started by RCA, the government claims that RCA does not own one patent that has been held valid in the courts. RCA can keep a so-called patent infringer tied up in court litigation indefinitely, just by charging that one or another of its 10,000 patents has been infringed.

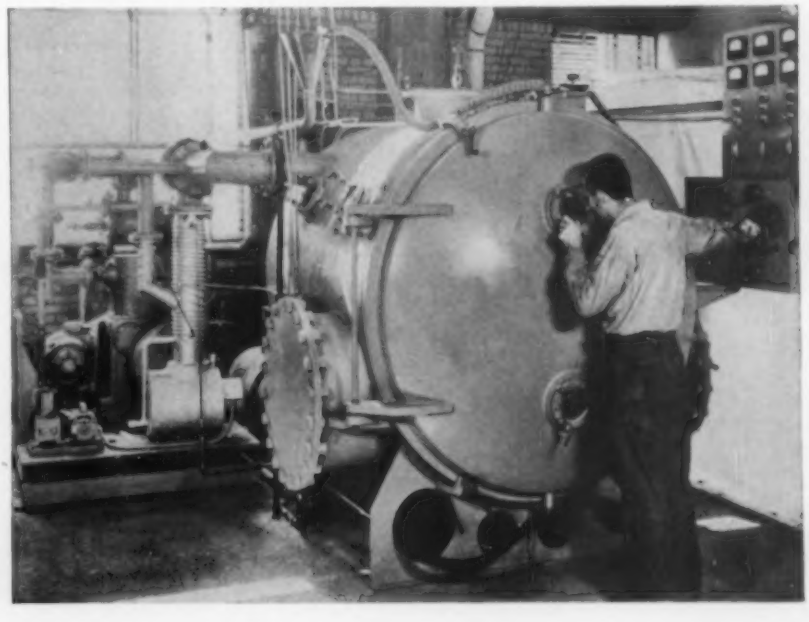
The government, besides asking for a ruling that RCA has a monopoly in the radio-TV patent licensing business, wants the package licensing agreements in effect declared illegal, and the exchange agreements between RCA and the co-conspirators (which do not expire until 1962 and 1971) cancelled. But the trust busters want more specific relief later, particularly relating to RCA's patents and the release of its know-how.

Larger Titanium Casting Furnace

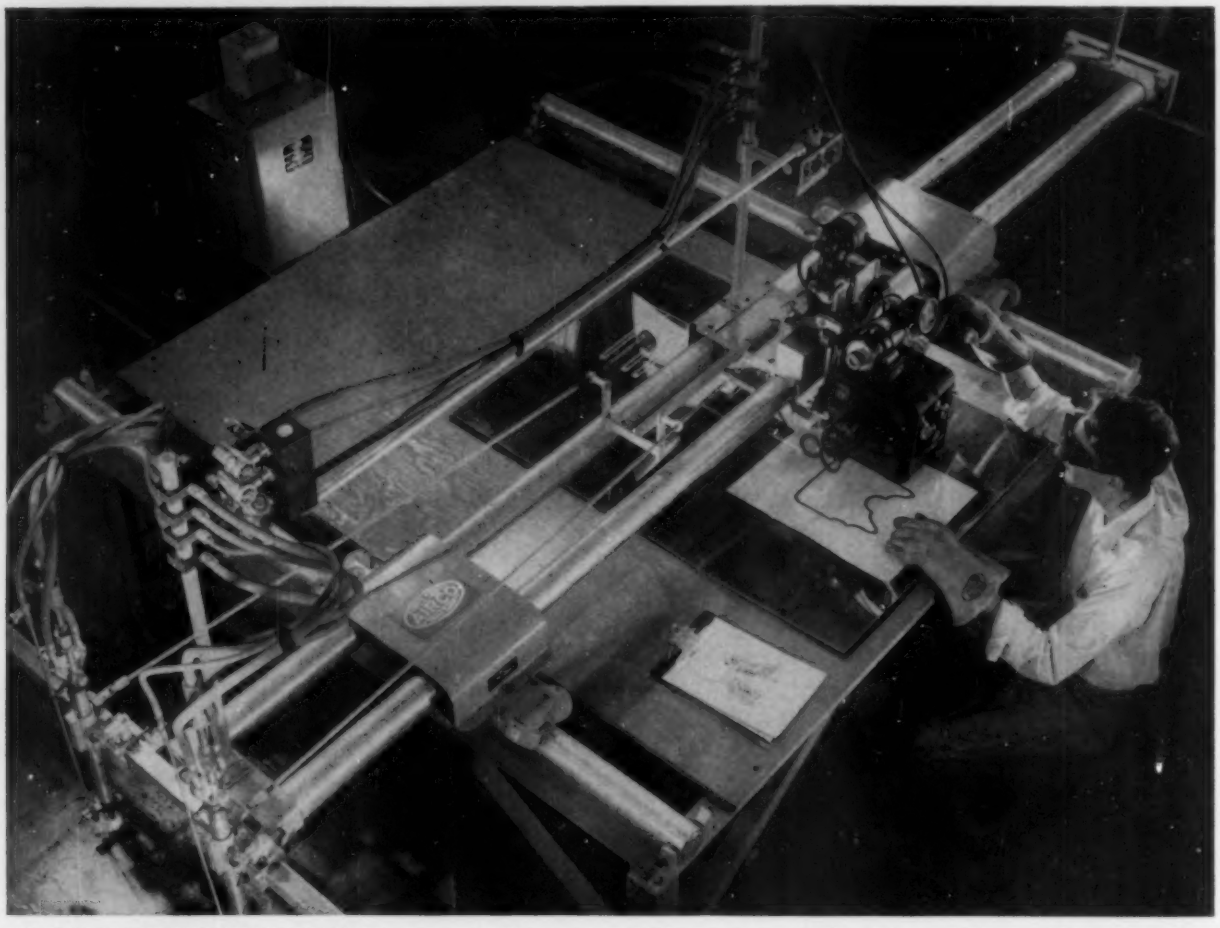
The Metallurgical Research Dept. of the National Research Corp. has added a new arc-melting vacuum skull furnace capable of pouring 50 pounds of titanium per charge. It was designed for use with the NRC titanium Shape Casting Process, or for the remelting of titanium scrap.

According to NRC, the larger size of this furnace will make possible the production of large castings, or several small parts at once, with important cost reductions. Now, sound castings are being made with the following typical interstitial content: Carbon, less than 0.02 per cent by weight; Oxygen, less than 0.06 per cent by weight; and Hydrogen less than 0.01 per cent by weight.

NRC claims that their titanium Shape Casting Process will produce sound castings of titanium and titanium alloys with a finish equivalent to that of good sand castings. An important feature is a mold material which withstands the action of molten titanium. The mold can be used repeatedly for casting titanium, as opposed to the carbon-graphite mold which can be used for one or two shots.

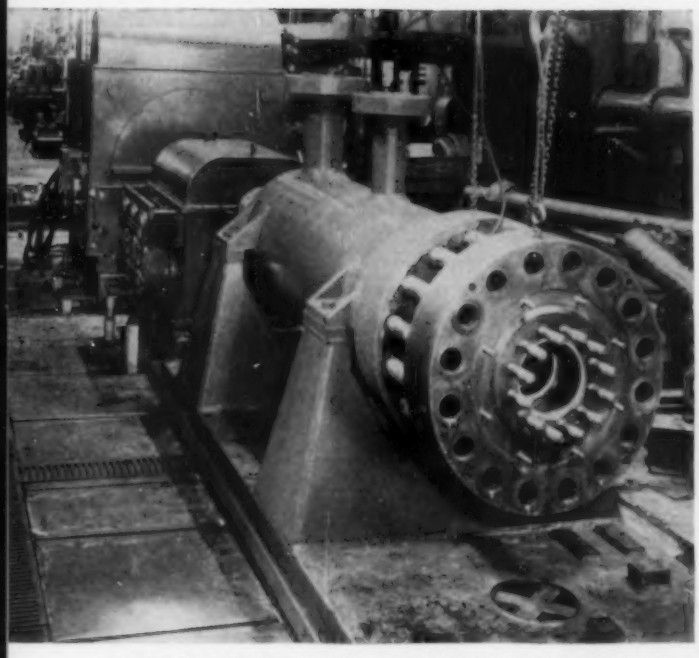


THE NEWS IN PICTURES



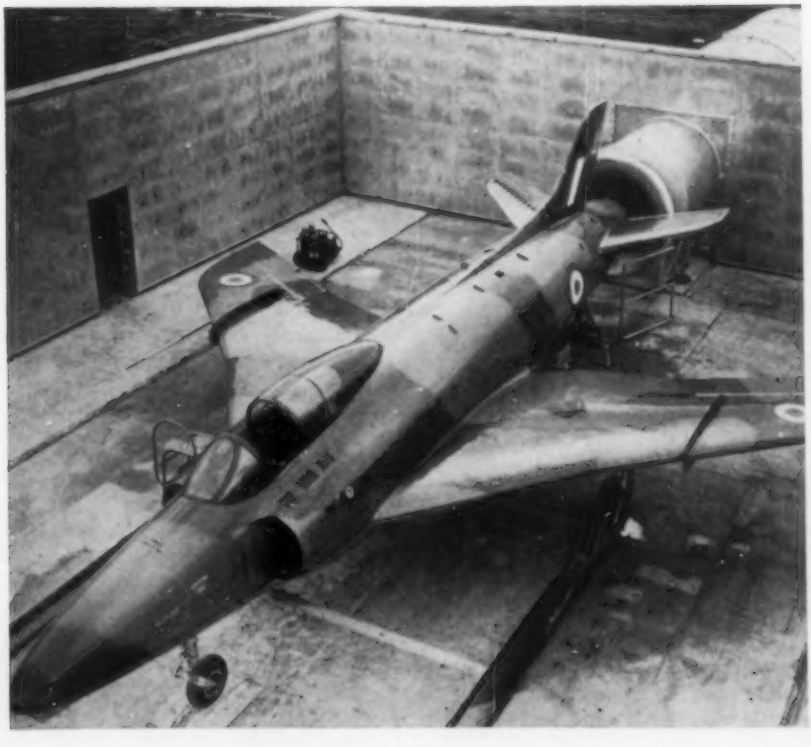
AIR REDUCTION CO.'s DUOGRAPH, a new rectilinear-type, medium area, oxyacetylene shape cutting machine with a four torch capacity. The cutting range of the machine, when equipped with one tracing table is 48 in. wide by 51 in. long. Four 48 in. dia. circles can be cut simultaneously with two torches at each end of the machine. Cutting length can be extended by the addition of extra tracing tables, measuring 80 in. each. Three different tracers: electronic (fully automatic, using paper cutout or pen-and-ink drawing templates); magnetic; and manual can be used. The cutting torches have pilot light assemblies.

A WIND TUNNEL ENGINEER at Boeing Airplane Co. inspects the new laminated glass-cloth fan blades recently installed in the company's transonic wind tunnel. There are two stages of 36 blades each, capable of pushing air at speeds up to Mach 1.2. The blade itself is 3 ft. long with an 18 in. plastic foam core, and weighs only 50 lb., which is comparable to the wood blades formerly used. The glass blade will take forces of 19 tons and temperatures of 200 F. The wood blades dried and split under these conditions. In making the blade, the plastic core is poured into the glass laminate shell, which contour is made by wrapping the glass cloth around a plaster mandrel.

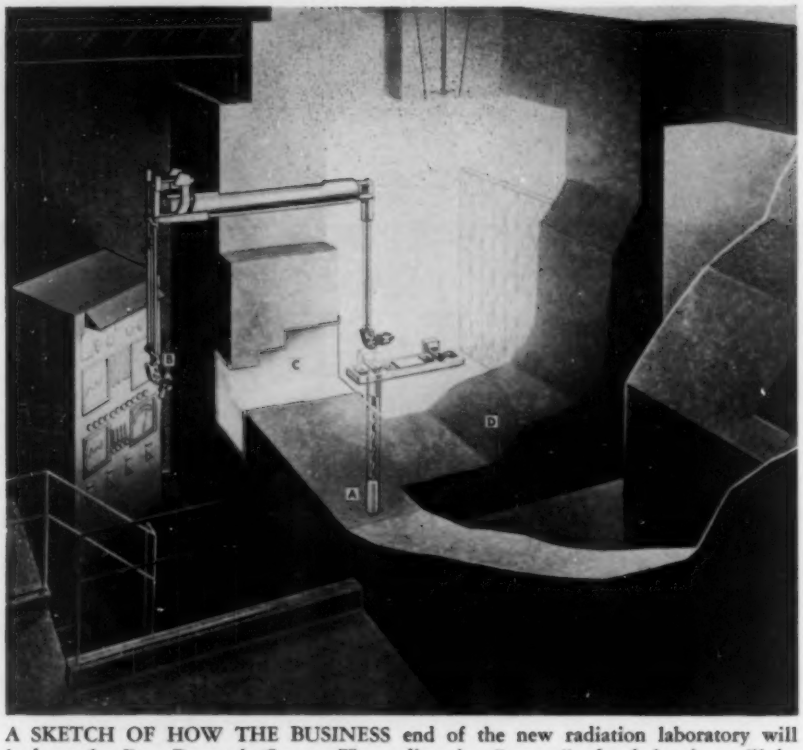


TO WITHSTAND THE HIGH OPERATING PRESSURES involved, this centrifugal boiler feed pump was inserted in a forged carbon steel reinforcing barrel 4 in. thick. This is one of six such barrels with end plates and piping nozzles, manufactured by Heppenstall Co. for United Centrifugal Pumps Company. Each pump is designed to deliver 1,300 gal. of 283 F feedwater per min., and can reach a discharge pressure of 3,400 psi. Pump casing, shaft, and the 13 impellers are of stainless steel. Shaft glands have close-fitting breakdown bushings. Pump drive is by a 2,250 hp, 3,600 rpm, 4,000 v motor through a fluid coupling, with speed variable between 2,800 and 3,500 rpm.

USING THIS COMBINED STRESS JOINT TESTER, engineers at General Electric can test their jet engine blades with a two-way stretch. With this machine it is possible to simulate the stress and strain put on jet blades by vibration caused in flight by air going through the engine, and by the centrifugal force of the revolving wheels. The large spring (top, right) can apply more than 18 tons of horizontal force on the blade, similar to that caused by centrifugal force, while the vibrating section supplies the vertical vibrations. The test is shown on an oscilloscope screen, and photographed to keep a permanent record of the amount of stress applied. Some jet engine blades are capable of withstanding over 30 tons psi.



THE BRITISH FIRM OF Vickers-Armstrong shows its method of cutting down the roar in aircraft factories when jet engines are tested at full throttle. Moved into the pen at left by tractor, this Vickers Supermarine Swift jet fighter, (in the 10,000 pound thrust class) has its exhaust centered in the opening of the muffler in the back wall. The muffler (above) reduces the noise level to the extent that it causes no annoyance at 1,000 yards, and in some directions, no noise at all at that distance.



A SKETCH OF HOW THE BUSINESS end of the new radiation laboratory will look at the Esso Research Center. The radioactive "source" of cobalt pipe will be located at the bottom of storage well "A" when not in use. Remote control handling will be done by the mechanical arms "B", and observed through a lead-glass window "C", which is over three feet thick. The concrete walls "D" are about four feet thick.

Oil Products Via Atomic Energy

In its continuous search for new and better ways of producing gasoline, motor oils, and lubricants, the Standard Oil Development Co. (S.O.D.) has now turned to atomic energy. In a new radiation laboratory, scheduled for operation next spring, scientists at S.O.D. will explore the use of gamma rays, emitted from radioactive cobalt, as a source of energy for inducing chemical reactions used in oil refining, and perhaps useful in the production of petrochemicals. Beyond this broad statement, the company declined to elaborate on what specific plans it had in the way of research projects. However, officials did say that they will not go into the chemical business. S.O.D. can take out patents on what they find, and are at liberty to make license agreements with other firms. But, they will not go into joint projects with any company.

Present petroleum refining processes involves heat, pressure, or catalysts, or a combination of the three. S.O.D. hopes that radioactivity will change some of these processes, and perhaps do away with some of the elaborate equipment now used. Or, it could either speed up some of the processes, or increase their precision.

Some scientists at S.O.D. feel that in the field of polymerization, atomic energy will be extremely useful. This process is used to transform certain petroleum and related raw materials into useful products, such as synthetic rubbers, lubricating oil additives, blending agents for aviation gasoline, and components of paints, inks, and other items.

S.O.D.'s new laboratory is the first privately financed venture of this type in the petroleum industry. The decision to build followed two years of research by company scientists using the facilities of the Brookhaven Laboratories.

The radioactive cobalt, which will be the "source", is in the form of a 13 in. pipe, 2 in. in diameter. It is being obtained from the Brookhaven Laboratories, where it has been undergoing neutron bombardment in an atomic pile for 2½ years. The strength of the "source" will be 3,500 to 4,000 curies at the time of delivery, making it the most radioactive single piece of cobalt known. It has a half life of 5 years. (A curie is approximately the amount of radioactivity given off every second by one gram of radium.)

Company scientists are looking forward to more powerful and less expensive radiation sources for use by industry. These sources might include radioactive by-products of atomic reactor operations, which the A.E.C. currently buries underground. Scientists also feel that it is possible to use the gamma rays now dissipated into shields surrounding the reactors.

Besides the work in the new laboratory, S.O.D. will expand its experiments on other uses of radioactive isotopes in research.

Tax Law Change Helps Researchers

Under a recent change in the tax law, grants to researchers up to $300 a month and extending for 36 months, are no longer taxable as income. In addition, a U. S. tax court has ruled that a grant made even under the old law should be considered as a gift, and not income as the Bureau of Internal Revenue had charged. In this case, an English professor who had received a $1,000 grant from the Guggenheim Memorial Foundation, won the fight to have the amount declared tax-free.

The big catch, however, is that under the new law and the court ruling, the grants must be made by tax-free, non-profit organizations. A business cannot award tax-free grants under the new law, but government officials expect an increase in the number of foundations established by businesses, so that a more liberal tax treatment can be given to researchers. Under the court's ruling, only an established researcher could apply, otherwise his "private interest" in the subject (no matter what) could not be demonstrated.

Tax officials are checking the new tax law for an answer to the question, before they file notice of appeal. The new law does not mention the "private interest" line of reasoning. It just says that scholarship and fellowship grants

from an educational institution, or tax exempt foundation can be excluded from taxable income up to the $300-and-36-months limits. The exclusion covers grants for travel, clerical help and equipment, as well as direct research, making the new provision broader than the court decision.

Researchers who have already paid taxes on grants under the Internal Revenue 1951 ruling, are inquiring about refunds under the new ruling. If an appeal is made, no refunds will be made until the matter is finally settled, which might take years.

New Government Office Of Technical Information —

A new office of strategic information has been set up in the Department of Commerce to advise government agencies, industry, and publishing companies on the release of technical information not subject to military security restrictions. The reason behind it is that much of the "grey zone" material that falls between the material classified by law, and the unclassified data can result in giving information to enemy nations.

This office will be headed by R. Karl Honaman, who is on loan from The Bell Laboratories in New York City, where he is Director of Publication. Mr. Honaman will report directly to Sec. of Commerce, Sinclair Weeks, and will work with industrial leaders, publishers, and federal agency officials in getting the new plan into operation. In announcing the new program, Weeks said that he was not talking about any form of censorship.

Honaman hopes that he can bring about the release of more, not less, technical information. This falls into three parts: (1) a voluntary program working with industry and with the public; (2) a policy on government publications in this "grey zone"; (3) an effort to improve the international exchange of technology. Under old treaties, for example, the U. S. is exchanging information with libraries throughout the world, including some in the iron curtain countries. Some of this material may not reach the public, or may be held up for a long time.

The first point in the program will revive the operations of the Office of Technical Services set up in 1951.

Coming Events ———

JAN. 24-28, 1955

12th International Heating and Ventilating Exposition, Commercial Museum and Convention Hall, Philadelphia, Pa. It will coincide with the 61st Annual Meeting of its sponsor, the American Society of Heating and Ventilating Engineers. Officials say that technical improvements will be prominent in all departments of the show, reflecting the influence of research on design. Among the "firsts" displayed will be a newly developed positive humidifier for warm air heat. In the field of air movement, there will be a primary exhibit of flexible tubing for branch ducting in both high and low pressure air conditioning systems.

JAN. 31-FEB. 4

AIEE Winter Meeting, Statler Hotel, New York. Because of the number of sessions, the symposiums and sessions will be held at both the Statler and the Governor Clinton Hotels. Besides the technical sessions a program of entertainment and inspection trips is planned. The registration of 5,000 at last year's show is expected to be exceeded.

FEB. 8-10

The 10th Conference of the Society of the Plastic Industry Reinforced Plastic Division, Hotel Statler, Los Angeles, California. Under the direction of Richard H. Malamphy of the Naugatuck Chemical Div., the conference is being planned around the theme: "The Industrial Progress in Reinforced Plastics in Important End-Use Areas." Tentatively, the committee plans to highlight the subjects of: transportation, including aircraft; tooling; automobiles; boats; trucks; reinforced plastics in the construction field, including panels both flat and corrugated; containers and machine housings; and corrosion resistant applications, such as pipe, tanks, ducting, and others.

FEB. 23

The Annual Winter Conference of the New York Section of the Instrument Society of America, at the Hotel Statler, New York. The theme of the Conference will be Scan-N-Log, Instrumentation for Data Reduction and Presentation, and the papers presented will cover, in part, some of the newest techniques of analog-to-digital converting, data scanning, and automatic logging.

MARCH 1, 2, 3

The 1955 Joint Western Computer Conference & Exhibit, at the Hotel Statler, Los Angeles, Cal. Sponsored by the IRE, the AIEE, and The Association for Computing Machinery, the theme will be "Functions and Techniques in Analog and Digital Computers." Technical papers and discussions will include descriptions of existing systems and techniques, methods of matching digital tapes and cards, language and communication problems between machines, and new developments in analog computers and computing methods. The exhibit will be limited to the products of manufacturers who make computers or major computer sub-assemblies. For more information write: William Gunning, Conference Sec., International Telemetering Conference, 2000 Stoner Ave., Los Angeles 25, Cal.

MAR. 28-APR. 1

Ninth Western Metal Exposition, Pan-Pacific Auditorium, and the Ninth Western Metal Congress, Ambassador Hotel, Los Angeles, Cal. Managing sponsor of the show will be the American Society for Metals and 20 other technical societies. ASM sessions will be devoted to the following topics: titanium; powder metals; high-strength steels; die materials and new forming methods for sheet metals; machining and tool materials; and metals used in the petroleum industry. Included are question-answer periods and round table discussions. Further information may be obtained from the Western Metal Exposition headquarters at the Ambassador Hotel, 3400 Wilshire Blvd., Los Angeles 5, Cal.

APR. 5, 6, 7

The National Fluid Power Association, 1955 Spring (Annual) Meeting at Colorado Springs, Colorado. More information may be obtained from B. N. Ashton, President of the Association, at 1618 Orrington Ave., Evanston, Ill.

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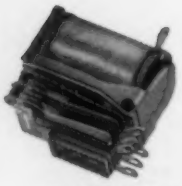
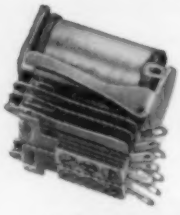


WHEN SIZE AND WEIGHT ARE LIMITING FACTORS...
Choose this smallest of all Automatic Electric miniature relays. Capacity: 6 contact springs. Weight: 1¼ oz. Dimensions: 1 11/16" x 1 5/16" x 11/16". *Specify: Series SQA Relay.*



WHEN GREATER CONTACT SPRING CAPACITY IS REQUIRED...
Choose this double pile-up relay—larger spring capacity in miniature. Capacity: 12 contact springs (up to 18 in some cases, depending upon operating requirements). Weight: 1½-2 ozs. Dims.: 1 11/16" x 1 5/16" x 1". *Specify: Series SQD Relay.*

WHEN ADDITIONAL COIL VOLUME IS IMPORTANT...
Choose this relay which accommodates a slug or sleeve for longer release and/or operate time; a second winding for holding, knock down, or separate operation; or greater winding volume for increased sensitivity or greater heat dissipating ability. Capacity: 12-18 contact springs. Weight: 2-4 oz. Dimensions: 2 1/16" x 1 5/16" x 1". *Specify: Series SLQ Relay.*

FOR EXTRA SENSITIVITY
The "sensitivity" of a Class "S" Relay can be doubled through the use of oversized coils (⅛" larger diameter than standard coils). For example: under favorable conditions, standard size coils permit operation of 1 Form "C" spring combination at 4 milliamperes, 24 volts dc; similarly oversized coils permit operation at 2 milliamperes, or less.

HERMETICALLY SEALED—SPECIAL MOUNTINGS
Class "S" Relays are available with or without plug mountings. A wide variety of hermetically sealed enclosures are offered for protection of single or multiple relays.

Two-Degree-of-Freedom Vibration Nomogram

ALEXANDER YORGIADIS
Consultant

This nomogram can be used to determine the two natural frequencies of linear, undamped, two-degree-of-freedom systems. These systems may be resolved with three masses and two springs as shown in System I, or with two masses and three springs as shown in System II.

The equations for their natural frequencies are:

SYSTEM I

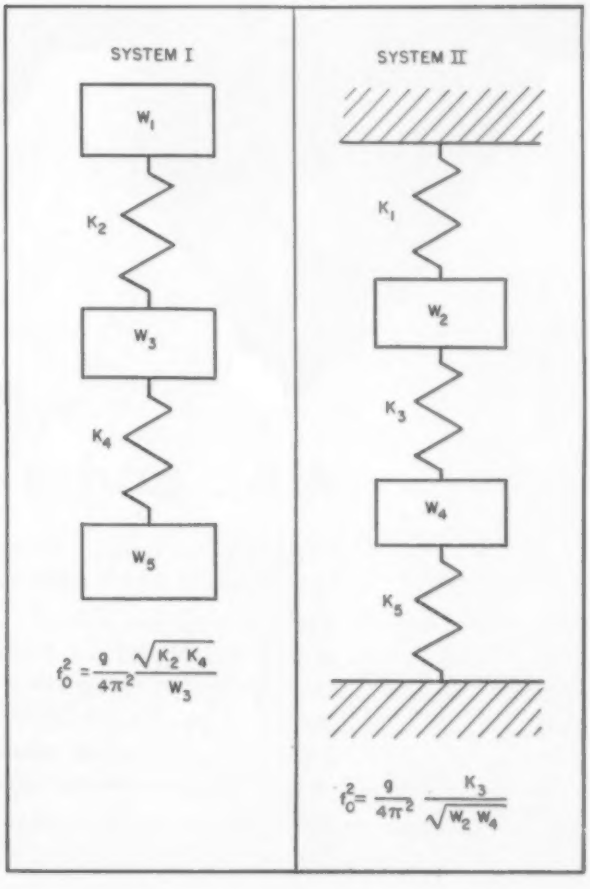
$$\frac{W_1W_3W_5}{g^2K_2K_4}\omega^4 - \left[\frac{W_1W_3 + W_1W_5}{g^2K_2} + \frac{W_3W_5 + W_1W_5}{g^2K_4}\right]\omega^2 + \frac{W_1 + W_3 + W_5}{g} = 0$$

SYSTEM II

$$\omega^4 - \left[\frac{K_1 + K_2}{W_2} + \frac{K_5 + K_3}{W_4}\right]g\omega^2 + \left[\frac{K_1K_5 + K_5K_3 + K_1K_3}{W_2W_4}\right]g^2 = 0$$

where

W = weight, lb
K = spring constant, lb/in.
g = gravitational constant, 386 in./sec²
ω_n = natural frequency, radians/sec
f_n = natural frequency, cycles/sec = $\frac{\omega_n}{2\pi}$



EXAMPLE

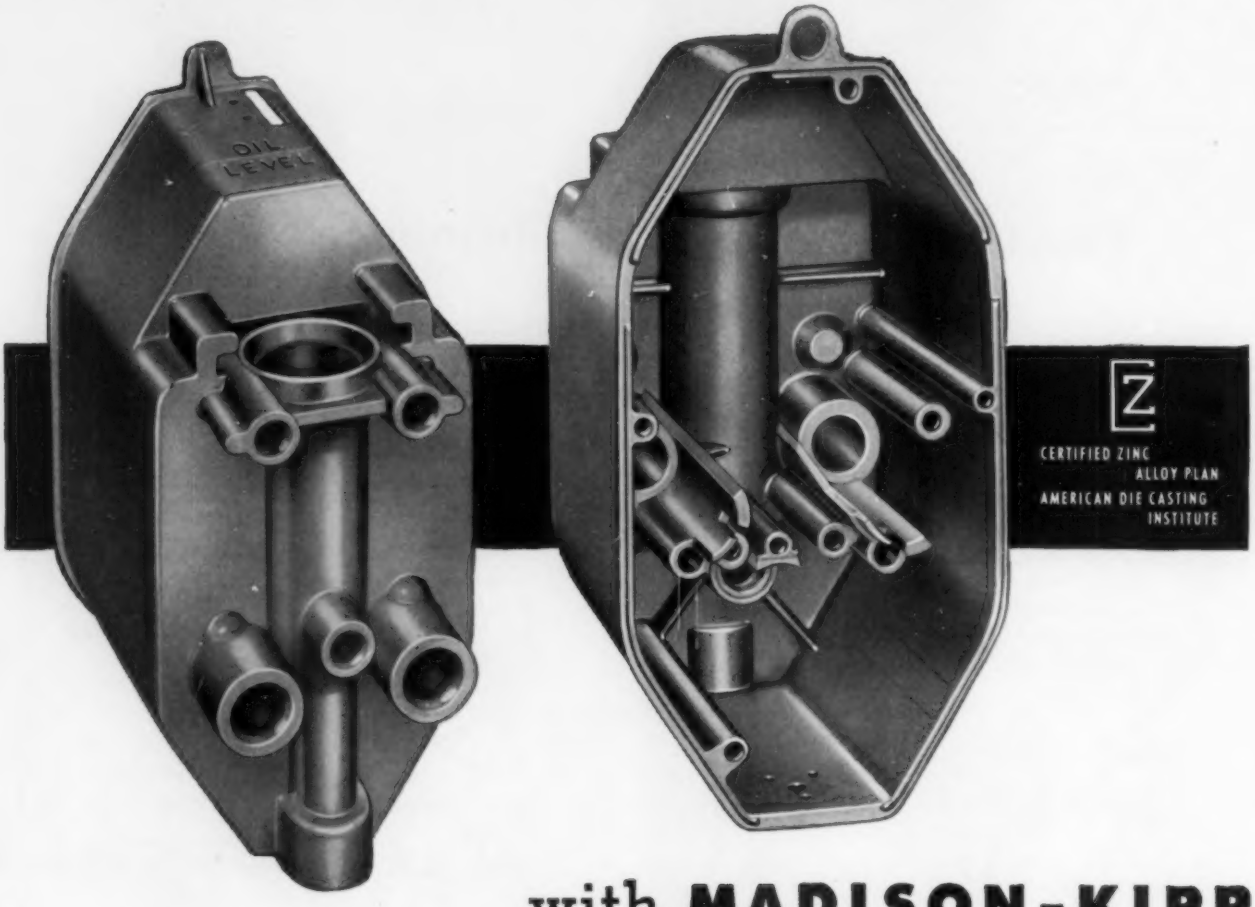
Find the two natural frequencies, f_n for System I with $W_1 = 0.57$ lb, $W_3 = 1$ lb, $W_5 = 445$ lb, $K_2 = 4$ lb/in., and $K_4 = 1$ lb/in.

Using the left half of chart, Fig. 1, and ratios $W_3/W_5 = 2.25$ and $K_4/K_2 = \frac{1}{4}$, locate point A. Draw a horizontal line from A to intersect ordinate 1 thus locating point B. Using ratios $W_5/W_1 = 1.75$ and $K_2/K_4 = 4$, locate points C and D (which is on ordinate 1 to the right of zero). Join BD to intersect zero ordinate at E. With BE as a radius, draw a circle to intersect the zero ordinate at F and G, thus obtaining values of 1.17 and 2.39 for f_n/f_e. Using the equation for f_e for System I, a value of 4.43 is calculated and the two natural frequencies of this system are:

$$f_{n1} = 1.17\ (4.43) = 5.18 \text{ cps}$$
$$f_{n2} = 2.39\ (4.43) = 10.6 \text{ cps}$$

(continued on page 207)

time tested designing...



with **MADISON-KIPP** zinc and aluminum die castings

Involved in the Oil Burner carburetor here illustrated is seasoned designing both by the principal and the die caster.

The product designer included a multiplicity of functions in one casting as the illustrations indicate. The die designing and the die making required expert handling by skilled craftsmen.

Millions of space heaters over the past quarter century have had as original equipment this or similar controls manufactured by Detroit Controls Corporation, Detroit, Michigan, with die castings made by Madison-Kipp Corporation.

When you have die casting requirements, please write to our home office in Madison.

kipp

MADISON-KIPP CORPORATION
206 WAUBESA STREET • MADISON 10, WIS., U.S.A.

• **Skilled in Die Casting Mechanics** • **Experienced in Lubrication Engineering** • **Originators of Really High Speed Air Tools**

Two-Degree-of-Freedom Vibration Nomogram (continued)

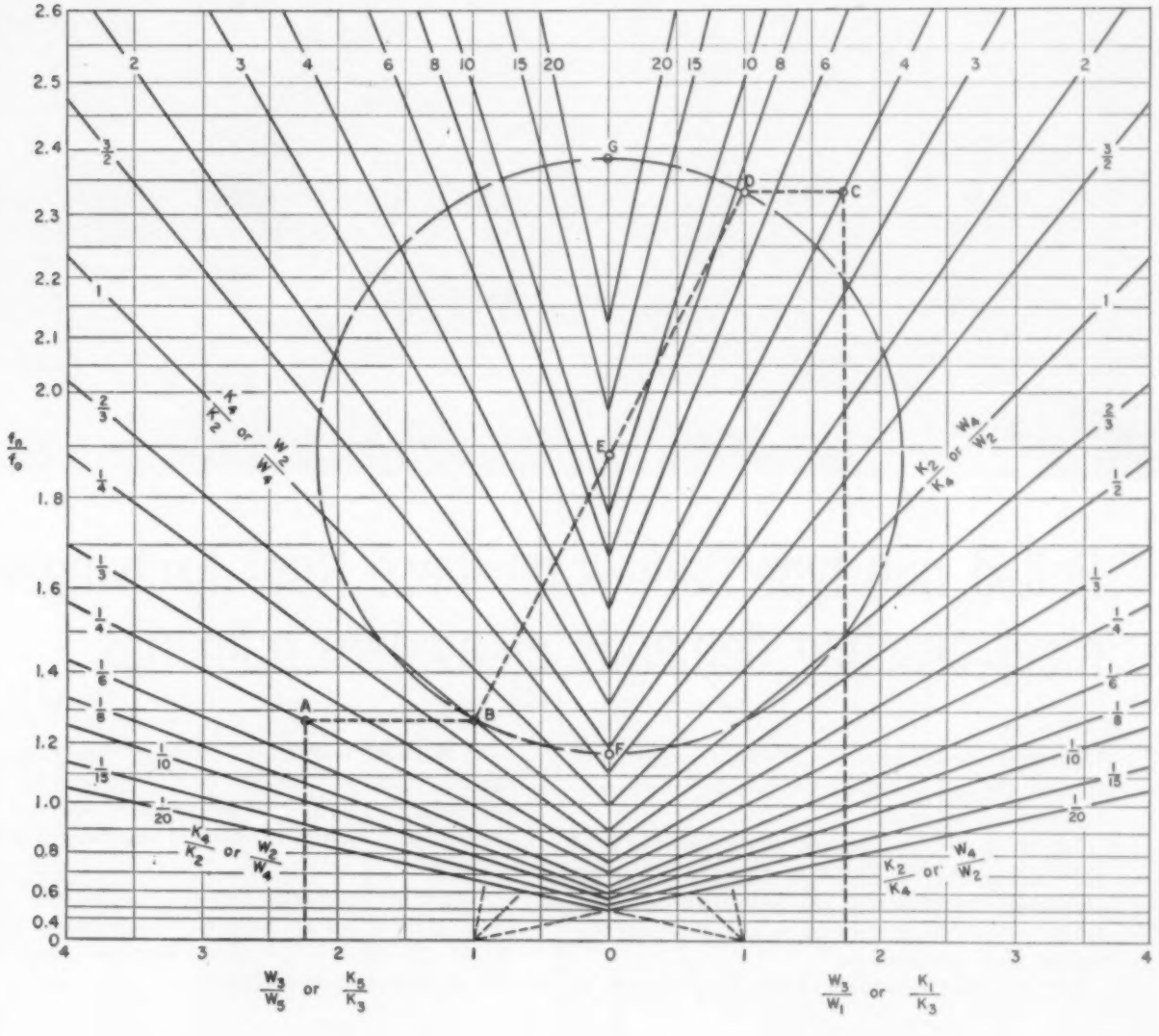
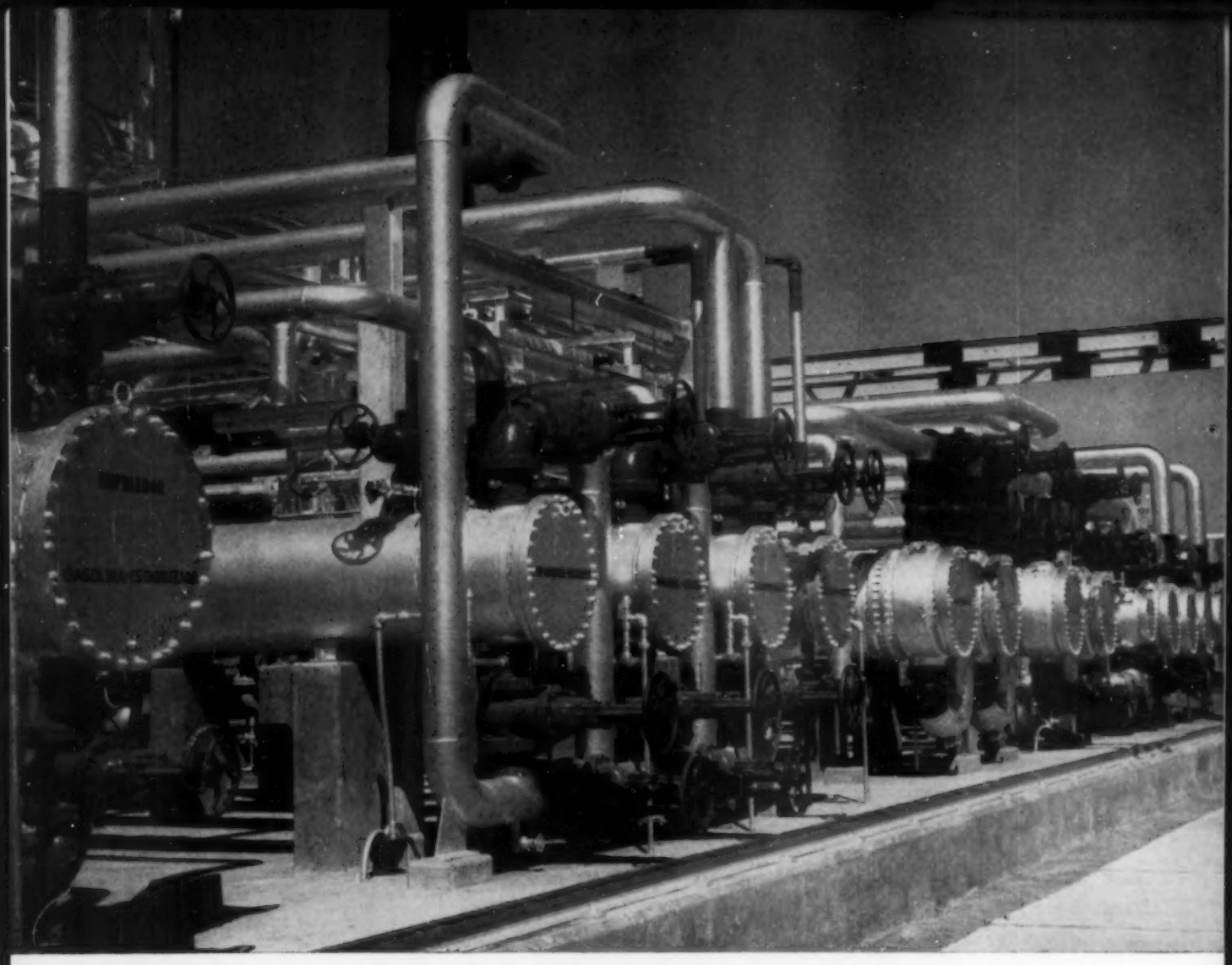


Fig. 1—Natural Frequency of Two-Degree-of-Freedom Systems



Rolled hub type flanges on these Ross Exchangers meet exacting demands of modern refineries

Modern petroleum refineries, like the one illustrated, demand the best obtainable in heat exchanger construction and materials.

The rolled, hub style flanges, on this line-up of Ross Exchangers, are an important example. They are universally recognized by all codes (TEMA, API-ASME, ASME), manufacturers and users, as the highest grade construction.

It'll pay you to investigate how you can benefit by using Standard Steel Works' rolled, weldless rings or flanges. Wherever you are now using castings or weldments, it's likely that we can show you how to improve your product or plant by switching to SSW forgings.

For further facts about how forgings can help you, please write to our Department 8935, Standard Steel Works Division, Baldwin-Lima-Hamilton Corporation, Burnham, Pennsylvania.

Standard Steel Works Division

Burnham (Mifflin County), Pa.

BALDWIN-LIMA-HAMILTON

General Offices: Philadelphia 42, Pa. • Offices in Principal Cities

Nomogram for Parabolic Cam With Radially Moving Follower

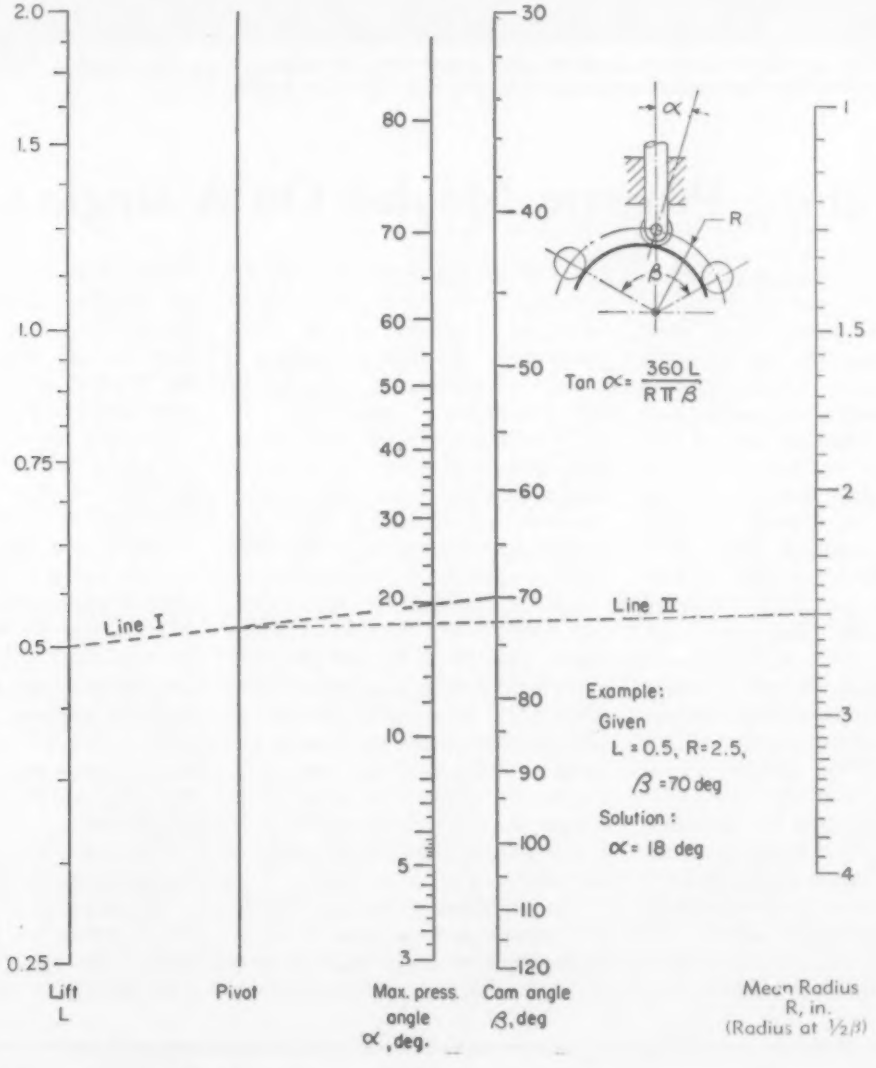
RUDOLPH GRUENBERG

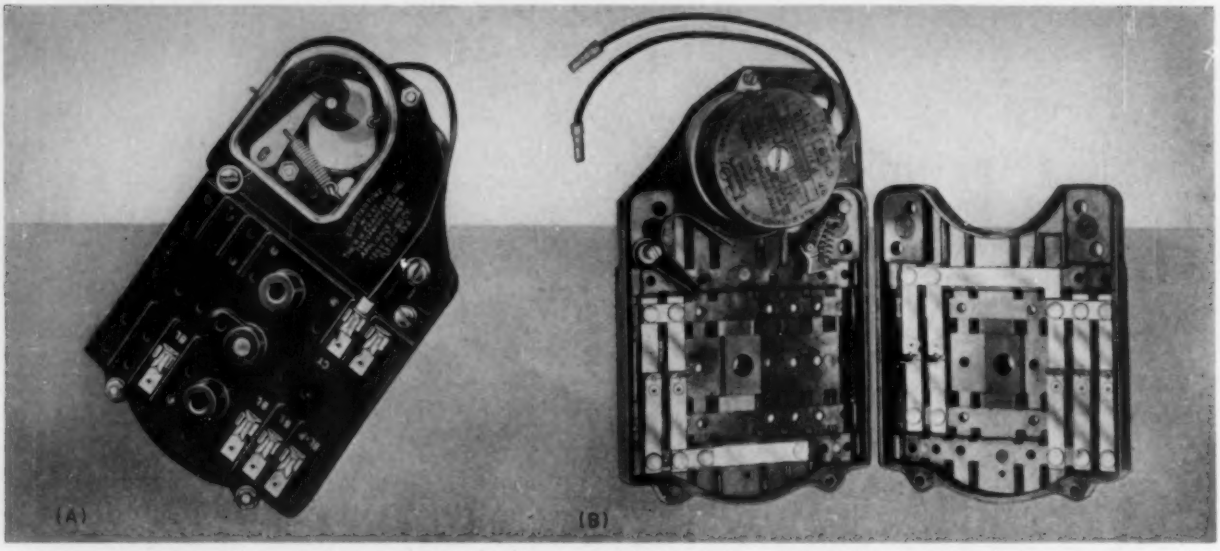
THE DEVELOPMENT of theoretically correct cam profiles is often complex and time consuming. In applications having neither high speeds nor forces, such efforts are unwarranted. In these applications, parabolic or gravity cams are usually adequate.

The efficiency of operating a cam-mechanism depends predominantly on the pressure angle. Since it is a measure of the greatest side thrust on the follower arm, the maximum pressure angle must be determined since it controls the physical dimensions of the cam.

The useful work transferred from the cam-shaft to the follower increases as the pressure angle decreases because the force component in the direction of the follower is proportional to the cosine of the pressure angle.

Designing for maximum efficiency, therefore, involves a trial and error balance of least maximum cam pressure angle against the mechanical limitations of the cam and its adjacent components. The nomogram below reduces this to a minimum and affords a quick check of an already established design.





(A) Timer for large appliances such as washers and other sequentially operating products has complete timing program molded on a single cam wheel. (B) Contact arms are kept simple: one is flat, the other has one bend.

Timing Program Molded On A Single Cam

This timer, for major appliances or other cycle-timed products, consists of a pair of molded plastic "clam" shells which fasten together and enclose a rotating bi-faced disc having a number of program-determining cam tracks or patterns and operating pairs of contact arms or poles, attached to the inner side of each shell. On the exterior are located suitable terminals for attaching electrical leads, which connect to the various units or components to be controlled. Extending laterally from the timer case is the driving motor. This is connected to the timer proper through a simple linkage which rotates the program cam intermittently in a series of regular steps, until an entire cycle of operation is completed.

The space required for the timer, motor included, is reported to be only half as much, measured from front to back, as that required for those now on the appliance market. This is said to meet the current trend toward combined splash aprons and instrument panels at the upper rear of major appliances. With fewer parts, all of which are functional and of simple construction, the timer is designed to permit interchangeable manufacture with a minimum of operations.

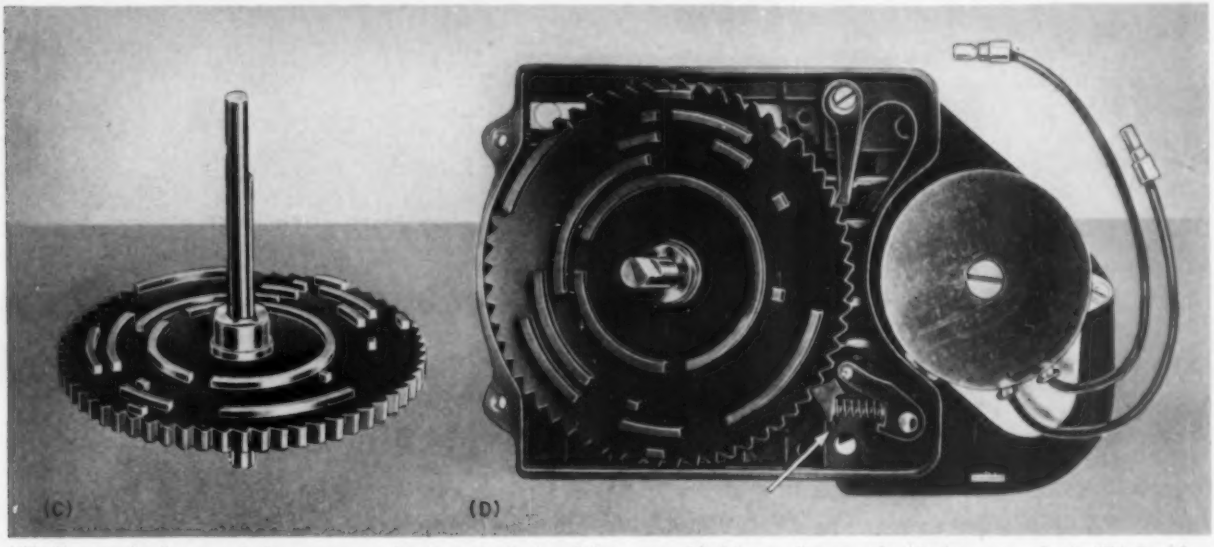
The principle of operation is simple and easily understood by salesmen, service men and users. It is quickly accessible to authorized personnel, but guarded against tampering. The timer has large capacity; it can operate from one pair to 12 pairs of contracts. Contact arms are simple, making for accuracy. One arm is flat, and the other has one bend only. Each pair of arms is assembled to a single part (half of case) so that proper relationship can easily be obtained. If it is ever necessary for the timer to be inspected in service, the relationship of the arms is not changed during disassembly of the case.

The two halves of the case, as made, are identical, and are made in a relatively simple two-piece mold, no cores or removable parts being necessary. When the two halves of the case are put together, a rigid box structure results. This box carries the main shaft bearings as an integral part of the housing, providing an accurate, permanently aligned assembly.

The cam tracks for each design are all molded integrally on the double face-cam, so that accuracy, without possibility of variation, is regularly obtained, and the problem of accurately keying a series of cams on a shaft is eliminated. The timer has potential capacity of seven cam tracks on each side. All the components, cam, contact arms, motor and actuating cam, indexing levers and detent pawl are adjusted during their assembly to a zero position. Once set at the factory, these settings should not require any change.

Most operating parts are made of powdered metal, lubricated for life.

The stepping action is visible, so that operation can be observed if desired. The locking detent pawl is quite sturdy, so that the timer can-



(C) Cam tracks for any timing sequence the timer is designed for are molded integrally on a double-face cam wheel. (D) Locking detent pawl (arrow) acts on the largest diameter of the cam to hold it in position, eliminating backlash.

not be turned backwards and contact arms damaged.

The motor is easily replaced. It requires 115 v, 60 cycle current and has an output of 3 w, of various speeds. The timer is best suited for service with appliance motors of about ⅛ hp, 20 to 30 ohm resistance level.

While a step motion is provided to insure rapid making and breaking of contacts, it is done through a simple transfer shaft having two attached levers. One is loaded by the motor cam and then released, at which time the other lever, through a pawl, inches or jumps the program cam ahead exactly one division. There are no trains of gears, or delicate parts. There also is no backlash, as the locking detent pawl acts on the largest diameter of the cam to hold it in position. The basic timer is designed so it may be attached to the appliance from either side; operating shaft and knob may be on either side, and manual rotation may be clockwise or counter-clockwise, as desired. Simple arrangements can be devised to meet any special condition, such as rotating from the edge or end. On and off switch can be combined with knob operation, or a current overload and on-off switch provided. R. W. Cramer Co., Centerbrook, Conn.

For more information—
Circle 1, inside back cover

Provides Strength In One or More Directions

A new glass-in-plastic laminate is reported to be uniform in properties and to eliminate the need for handwork in "lay-up" or production. The new engineering material consists of one or more uncured (unhardened) sheets of plastic. Each of these layers is integrally reinforced with linearly aligned, continuous, closely spaced glass filaments.

These filaments, as well as the curing agent in each sheet, are uniformly dispersed, and the filaments are aligned straight and parallel in shoulder to shoulder fashion without crimp, slack or twist, the manufacturer has stated. Each sheet is composed of 60 percent glass and 40 percent plastic resin by weight.

Three forms of the new material are currently available: 1) if strength is desired in just one direction in each ply of the laminate; 2) if a strength relationship is required in two principal directions, then a lamination can be supplied where the filaments run in the two necessary angles; 3) if equal strength is desired in all directions, then sheets of the material are laminated together at 120 deg angles to produce what the maker calls an "isotropic laminate." When processed and hardened this form gives equal strength in all directions in the laminating plane.

The resulting reinforced plastic may

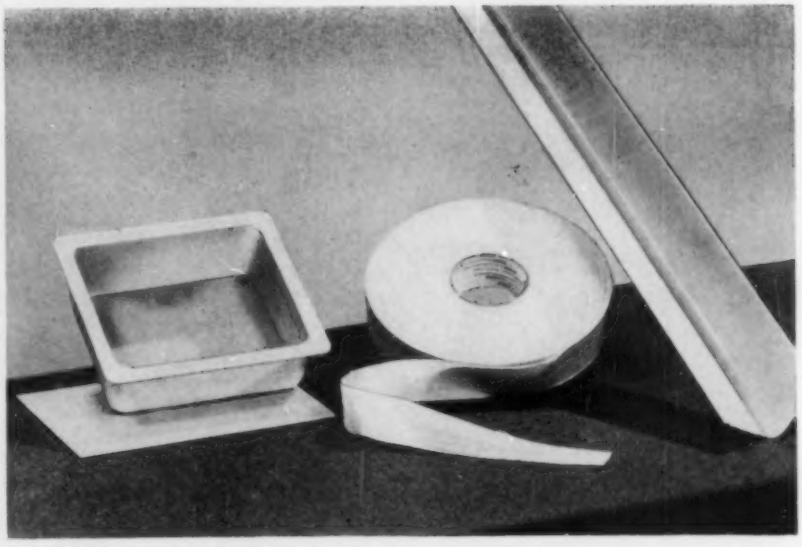
CONTINUED ON PAGE 212

or cured by heat and light pressure. No further chemical treatment is required, and the only preparatory step necessary prior to molding is to remove the protective paper liner from the surface of the material. Ready to use for drawing operations in much the same manner as sheet steel, and since molding forces are kept small because forming is done before curing, forming this material is said to be easier than steel.

The new material is especially adaptable for the matched metal or plastic die method of molding, but can also be processed into its final cured state by any of the other commonly-known molding techniques in use today, including the pressure-bag and vacuum-bag methods. Present cure time is 35 min at 330 F, under a molding pressure of 25 psi. This time can be shortened to as little as a few minutes on equipment operating in the 350 to 450 F temperature range.

Properties for the isotropic laminate include: tensile strength (ASTM D638-52) of 41,000 psi; flexure strength (ASTM D790-49T) of 64,500 psi; compressive strength (Fed. Spec. L-P-406b Method 1021.1) of 42,000 psi; heat distortion (ASTM D648-45) at 264 psi of 350 F.; and dielectric strength of 700 v per 0.001 in. It is also inert to usual industrial acid or alkaline atmospheres and salt air.

The nature of the product—composite plies of unitary layer structure—also permits special forms of the high adhesion epoxy resin to be supplied to the molder. Included are various ready-to-mold colors, wood grains, metal foils or other finishes that are built right into the top or surface layer of the uncured laminate.

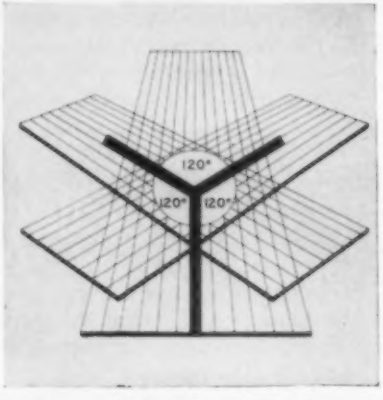


GLASS-IN-PLASTIC LAMINATE is available in sheets or rolls.

In its cured form the material is said to be shatterproof, rotproof, mildewproof, and waterproof. It can be sawed, sheared, punched, drilled, sanded, painted, cemented and polished.

Average storage or shelf life for the uncured material is about 30 days under normal room conditions, but this can be upped to four months or more when stored at constant 40 F temperature.

The new plastic material is being sold by the pound in pilot-plant quantities, and is supplied in sheets or rolls depending on thickness. Minnesota Mining & Mfg. Co., 900 Fanquier St., St. Paul 6, Minn.



GLASS FILAMENTS can be laminated into this new plastic sheet in straight, parallel fashion, in any two required directions or in three 120 deg angles.

For more information—
Circle 2, inside back cover

Oil Fog Lubricators for Air-Operated Equipment

A recently introduced line of lubricators for air tools, air cylinders and other air-operated equipment has an adjustable variable vane venturi which is reported to permit one unit to meet the requirements of a much wider range of operating conditions and handle applications which previously required several sizes of lubricators. For example, at 80 psi the $\frac{3}{8}$ in. size can be set for a low flow range of 5 to 9 cfm, a high range of 50 to 100 cfm, or any intermediate range desired. Models in pipe sizes of $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in., are available with capacities of $\frac{1}{2}$ pt, $1\frac{3}{4}$ gal, and $4\frac{1}{2}$ gal, from 5 to 250 cfm at 80 psi.

An auxiliary air circuit controls the oil feed, from one drop in 20 min to 15 drops per min. A constant oil level eliminates the possibility of the rate of oil feed being affected by the quantity of oil in the bowl. C. A. Norgren Co., 3428 S. Elati St., Englewood, Colo.

For more information—
Circle 3, inside back cover

CONTINUED ON PAGE 214

Your Products Deserve Aeroquip Hose Lines

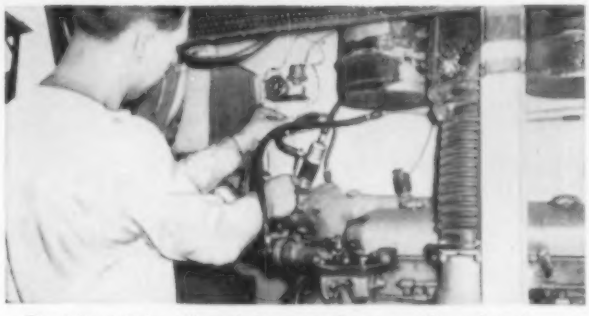
See Aeroquip products on display, Booth No. 544, at the Plant Maintenance and Engineering Show, January 24-27, International Amphitheatre, Chicago.

BECAUSE

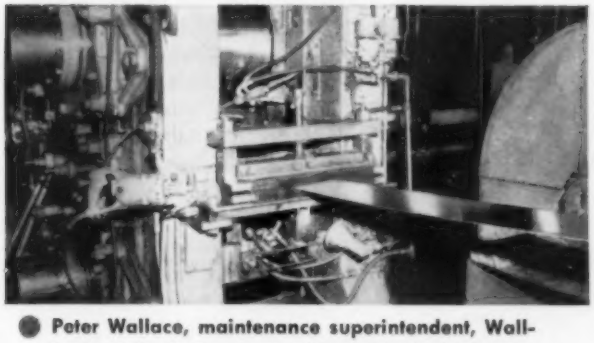
YOUR CUSTOMERS PREFER AEROQUIP

READ WHAT THESE TYPICAL EQUIPMENT OPERATORS SAY:

● **Nick Martino, master mechanic, of American Construction Company, Inc.: "Aeroquip's superior quality hose and reusable fittings mean less headaches due to downtime."** (*Operators of construction equipment*)



● **Albert Schardl, maintenance foreman, New Britain Transportation Company, Inc.: "Aeroquip has prevented road failure due to hose breakage. Within the next six months we expect to be 100% Aeroquip . . ."** (*Bus operators*)



● **Peter Wallace, maintenance superintendent, Wallingford Steel Company: "Aeroquip is better because of quick installation. It stands continuous abuse and increases safety."** (*Operators of steel rolling equipment*)

● **Al Herbert, superintendent, National Welding Manufacturing Co.: "We had worlds of trouble with pipe and fittings breaking from vibration. Aeroquip solved this problem. Now we are standardized on Aeroquip."** (*Users of air tools*)

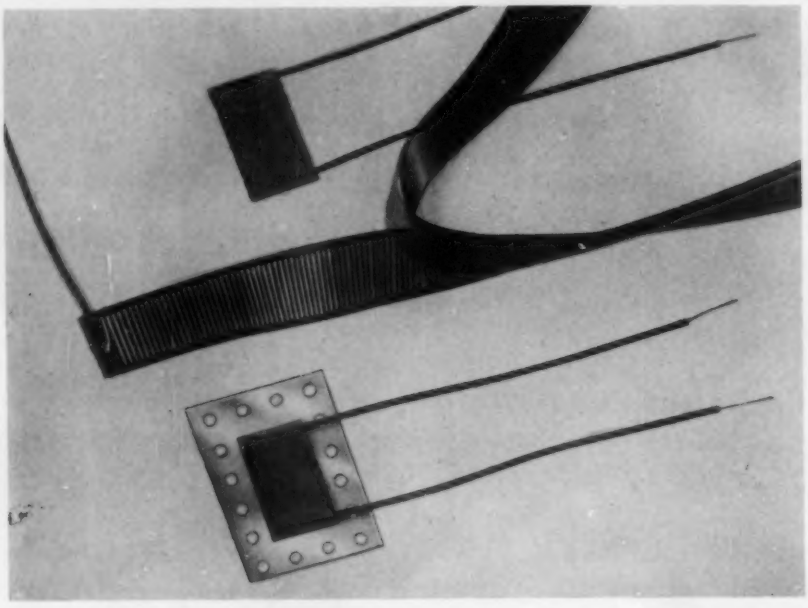
Engineering assistance is available . . . write for complete information.

Aeroquip

REG. TRADE MARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD ● AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD



Flexible Electric Heating Elements

These electric heating elements take the form of flexible blankets or strips, as illustrated. For ease of mounting or for the purpose of reducing flexibility, they are also offered with a perforated stainless steel backing.

Their thinness (0.100 in. or less) and flexibility are said to allow installation at the place of need. Light weight is often a factor in their selection, as is their ability to operate under pressures in excess of 100 psi.

The insulation used is silicone rubber and glass fiber cloth. The assembly can withstand continuous operation at temperatures in excess of 450 F.

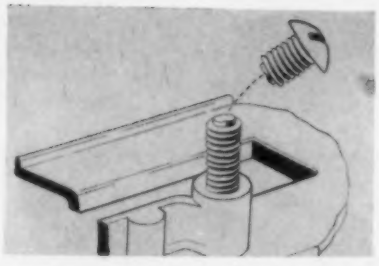
Standard elements are available in a variety of sizes from 1 by 1½ in. overall to 24 x 42 in. Resistance variation is infinite throughout a wide range; tolerance is ± 7 percent. Electro-Flex Heat, Inc., Dept. D-10, 516 Asylum St., Hartford 5, Conn.

For more information—
Circle 4, inside back cover

MECHANICAL COMPONENTS

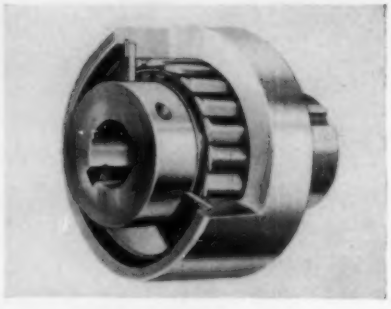
Thread-Cutting Break-off Screw

A break-off thread-cutting screw forms a stud in the cored holes of die castings. Potential applications include automotive tail light assembly, refrigerator nameplates or decorative escutcheons of various types.



The screw, which can be hopper fed from power screw drivers, is driven into the untapped cored hole until it "bottoms." Torque is then increased and the upper portion of the screw including the head twists off at a "necked down" section of the screw. This leaves a protruding stud on which a nut can be easily threaded. The head portion may be designed for re-use in a different type of application. Illinois Tool Works, 2501 N. Keeler Ave., Chicago 39, Ill.

For more information—
Circle 5, inside back cover



Cam Clutches For Low-Speed Low-Torque Applications

Low-cost, plain bearing cam clutches for indexing, overrunning abd backstop applications are basically designed for operation in the lower speed and torque ranges and can be used in conjunction with standard shafting on press feeds and two-speed drives.

These self-contained units include a long bronze bearing, hardened and ground steel inner and outer races, a full complement cam and energizing spring assembly, a snap ring and a grease fitting for lubrication. The clutches are prelubricated at the factory.

The hardened ball bearing steel cams have a constant-pitch spacing design that avoids cam crowding and single cam locking conditions. Shape of the cams is such that they cannot roll over under overload or peak torsional loads. A flat contour beyond the locking position contacts the outer race at loads above normal capacity rating and prevents the cams from injuring the races or damaging the energizing springs. The contact angle is designed to prevent the cams from skidding out under load.

The bronze bearing is machined for a running fit on the shafting. The inner race is ground to closer tolerances to provide either a sliding or slight press fit depending on customer's shaft

CONTINUED ON PAGE 216

a CMP cost cutting report

ON THIS DRAWN METAL PART...

CMP COLD ROLLED STRIP STEEL

(NON-SCALLOPING QUALITY)

eliminated earing and an extra operation .... stepped up production

BEFORE

Buying a standard specification cold rolled strip steel this manufacturer had several fabrication problems. Needing a precision assembly fit with other components, they frequently had runs of many rejects and production slow-downs. Inspection costs for in-process fabricating was excessive. Each unit, after drawing, also required an additional trimming operation to remove the ears. Because of the uniformity needed, costs were running out-of-line and the added manual work to reclaim rejects was further increasing costs.

AFTER

First, a suggestion from a CMP representative gained interest and established several meetings with production and engineering to consider the CMP proposal. Several test runs were made with the non-earring CMP specification steel developed specifically for this job. It worked wonders. the trimming operation was eliminated completely and a precision quality for uniformity was established. A close, dependable assembly of components was made possible, eliminating the "re-work" line entirely. Rejects were reduced to an absolute minimum. Perhaps you could improve your product and production, too, with CMP "specific specs" cold rolled strip steel — we will be glad to work with you.

CMP . . .
WHERE YOU CAN GET SPECIFIC SPECS. FOR SPECIFIC JOBS

LOW CARBON
HIGH CARBON
Annealed or Tempered
STAINLESS
ALLOY
ELECTRO ZINC COATED

the Cold Metal Products co.

GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN, OHIO AND INDIANAPOLIS, INDIANA
SALES OFFICES: New York • Cleveland • Detroit • Indianapolis; Chicago • St. Louis • Los Angeles • San Francisco

LOW CARBON, HIGH CARBON (Annealed or Tempered), STAINLESS AND ALLOY GRADES, ELECTRO ZINC COATED ARE AVAILABLE FROM:

THE COLD METAL PRODUCTS CO. OF CALIFORNIA
2131 South Garfield Avenue, Los Angeles — Phone: RAymond 3-4581

THE KENILWORTH STEEL CO., 750 Boulevard, Kenilworth, New Jersey
Phones: N. Y., COrtlandt 7-2427; N. J., UNionville 2-6900

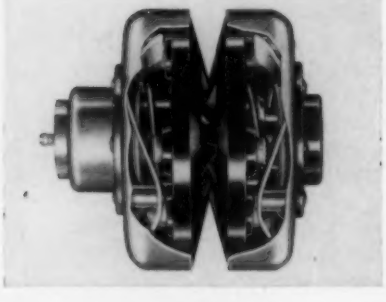
PRECISION STEEL WAREHOUSE, INC.
4425 W. Kinzie, Chicago — Phone : COlumbus 1-2700

specifications. The hub on the outer race has a precision ground outside diameter with a standard keyseat.

These new cam clutches are made in seven standard sizes, ranging from 2-in. OD by 2-in. long to 5¼-in. OD by 4⅜-in. long. The smallest cam clutch, the Model PB-3, is rated at 8.2 ft-lb torque, indexing; 16 ft-lb, general duty; and 23 ft-lb, backstop. It weighs about ½ lb and has a ⅜-in. max bore with keyway and setscrew. The hub has a ⅛ by 1/16-in., ⅝-in. long keyseat.

The largest cam clutch in the line, the Model PB-14, is rated at 545 ft-lb torque, indexing; 1,075 ft-lb, general duty; and 1,584 ft-lb, backstop. It weighs about 13¼ lb and has a 1⅜ in. max bore with standard keyway and setscrew. The hub has a 7/16 by 7/32-in., 1⅜-in. long keyseat. A maximum speed of 1,500-rpm is recommended for the Models PB-3, 5, 6 and 8. A maximum speed of 800-rpm is recommended for the Models PB-10, 12 and 14. Morse Chain Co., 7601 Central Ave., Detroit 10, Mich.

For more information—
Circle 6, inside back cover



Belt Pulley Provides Variable Speed

A belt pulley is said to permit infinitely variable speeds from a constant speed motor. Turning a handwheel on a standard base moves the motor assembly toward or away from the driven pulley, allowing a standard V-belt to run over the variable pulley's various pitch diameters. Movement toward the driven pulley produces the maximum speed variation, while movement away produces the minimum. The pulley was designed to compensate for changes in production schedules and variations in materials and atmospheric conditions, the manufacturer states.

It is the cam and cam follower assembly on the back of the pulley faces that allows the pulleys to adjust automatically to maintain a given speed with large load variations. The unit's face assembly can be replaced without replacing the entire pulley. Springs in the pulley serve only to keep the pulley faces in contact with the belt at all times and are not driving members, so they do not compress the belt with excessive pressure.

These new pulleys are made in seven models. The model to be used depends upon the size of the motor involved. Maximum horsepower recommended (at 1750 rpm) ranges from ½ to 5 hp. Pulleys are also available with dual-ratio and countershaft bases. Equipment Engineering Co., 2853 Columbus Ave., Minneapolis 7, Minn.

For more information—
Circle 7, inside back cover

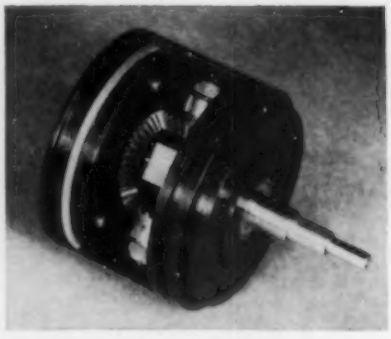
Vibration Mountings For Small Engines

Formerly, outboard motors transferred most of the motor vibrations and noise to the boat hull—which acted as a "sounding board" and magnified these noises to an annoying level. A new mounting, similar in principle to the engine suspension system aircraft, is said to provide the necessary flexibility for vibration isolation at all speeds. At the same time it provides stability for steering. Lord Mfg. Co., Erie, Pa.

For more information—
Circle 8, inside back cover

Single-End, Concentric-Shaft Differential

The output and both inputs of this differential extend concentrically from one end of a servo-mounted case. This makes it possible to mount the unit like any standard servo motor resulting in a single line gear train. Gears are mounted on ball bearings. Overall diameter is 1¾ in. Overall length (including 0.3742-in. dia shaft, 1-7/32-in long) is 2-2/32 in. Trans-American Precision Instrument Corp., 34-17 Lawrence St., Flushing 54, N. Y.



For more information—
Circle 9, inside back cover

Miniature All-Metal Vibration Isolators

These miniature mounts meet military specifications, including the ability to maintain a damping and isolation effectiveness at extreme temperatures (tested from −60 to 175 C). They are capable of being attached directly to the equipment, of being incorporated into mounting bases or, because of their minute size, they can be used internally.

Designed to protect airborne equipment, the mounting measures 1 in. in height and is constructed of metal, exclusively. It is available in four series, all of which have the same load ratings (ranges covering from 0.9 to 3.0 lb). They differ only in the location of the mounting plate and in the number of mounting holes.

The mount contains a stainless steel spring, which supplies the resilience and deflection necessary for isolation in supporting the load. A formed wire mesh snubber cushions those shocks which are large enough to bottom the load-carrying spring. The snubber is effective in all directions in preventing the aluminum core from hitting the mount's outer shell.

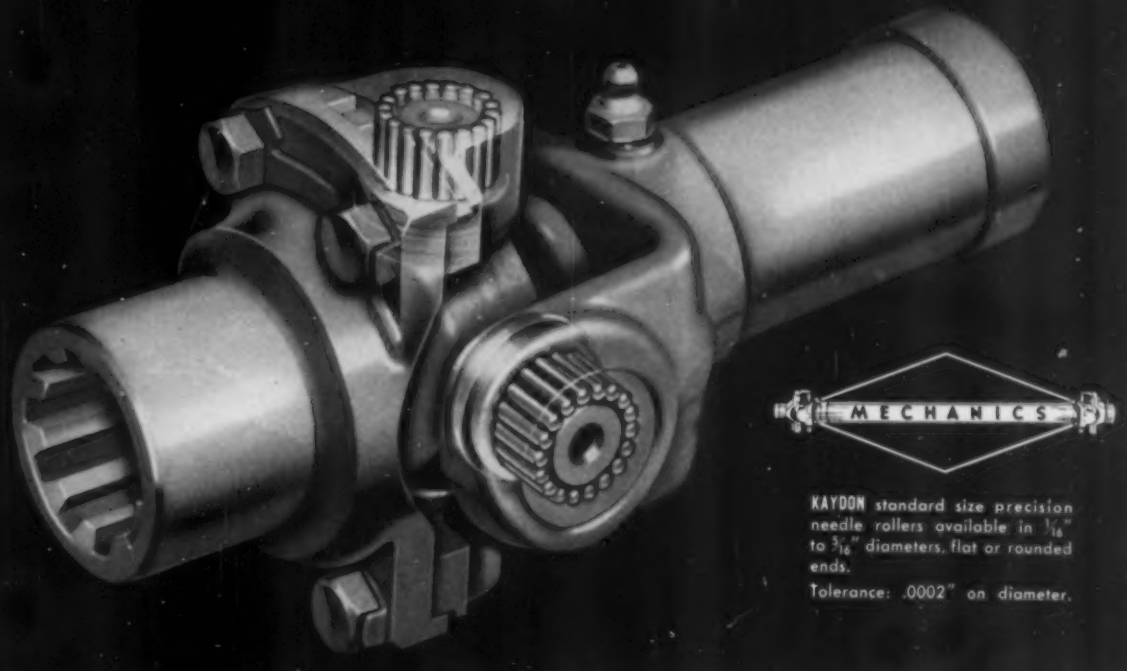
Damping is obtained in the M-24 series by the friction between the core's inside and the wire mesh cylinder. This design feature eliminates any great deflection of the wire mesh damper, preventing packing of the damper and eliminating the problem of loose

CONTINUED ON PAGE 218

Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

Engineered for 50,000,000 revolutions without added lubrication



KAYDON standard size precision needle rollers available in 1/16" to 3/16" diameters, flat or rounded ends.
Tolerance: .0002" on diameter.

KAYDON high-precision needle rollers used in MECHANICS' universal joints

KAYDON high-capacity, precision needle rollers are an integral part of automotive and truck universal joints built by Mechanics Universal Joint Division of Borg-Warner Corp.

KAYDON's low-cost needle rollers perform economically and efficiently at low or high speeds — continuous or intermittent operation. What's more, they're performance-proved for 50,000,000 revolutions or 20,000 miles without additional lubrication.

If, like Mechanics, you manufacture large or small universal joints, requiring needle rollers or any type of ball or roller bearing for applications in aviation, industrial, mining, agricultural and other industries — it will pay you to contact KAYDON of Muskegon.

Write for Catalog!

For complete data on capacity, design, separators, standard and custom designed KAYDON *Reali-Slim* bearings, write for this 24-page catalog, No. 24.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-5410

PRECISION BALL AND ROLLER BEARINGS

particles. Careful control of the amount of damping is used to insure optimum performance. Barry Corp., Watertown, Mass.

For more information—
Circle 10, inside back cover

Fully Enclosed Vibration Mountings

This spring-type vibration isolating unit is of telescopic construction, fully enclosed in a semi-steel housing. The new units are said to offer increased carrying capacity without increase in physical size. They come factory preset, but may be readjusted at any time in the field.

Resilient guides contained within the upper portion of the housing are completely protected from oil drippings, dirt, waste. These resilient guides offer all-direction snubbing and damping. Inspection windows permit checking of adjustment and operation. Complete installation and adjustment instructions are permanently affixed to each unit. Vibration Mountings, Inc., 76-19 Queens Blvd., Elmhurst 73, N. Y.

For more information—
Circle 11, inside back cover

Centralized Lubrication System For Individual Machines

Automatic application of fluid lubricants to bearings on individual industrial machines at predetermined intervals is provided by an air-operated centralized lubrication system. This system was developed, according to the manufacturer, to fulfill the need for servicing machines operating at varying rates of speed where applications of lubricant at varying intervals may be required.

Control may be by any one of three methods: (1) mechanical control, using motion of the machine to actuate an air valve which in turn cycles the lubrication system; (2) electrical control, employing an adjustable time clock to actuate a solenoid air valve which in turn cycles the lubrication system at intervals of 7½ min to 3 hr; and (3) manual control, using an air valve actuated at machine operator's discretion. The system includes an automatic safety control which stops the machine if air supply to pump fails, lubricant reservoir is empty or lubricant supply line is damaged. Lincoln Engineering Co., 5737 Natural Bridge Ave., St. Louis 20, Mo.

For more information—
Circle 12, inside back cover

Contant Level Oilers

These oilers automatically maintain a constant level in components such as large ring or ball bearing chambers, pump and gear housings, textile comb boxes. It can also be used to maintain a constant level of water in equipment that moistens humidifiers, tobacco, fabrics, felt pads, large gummed tape machines or wherever a constant level in a reservoir is desirable.

The manufacturer states that these new oilers are designed to feed a complete range of oil viscosities. Large surge capacity is provided for any back surge caused by a large amount of oil draining off mechanism when machine is stopped. Reservoirs of 10 oz. are available in plastic or glass, and metal parts are machined brass. Base is made of cast aluminum. All joints are electronically silver-brazed for maximum strength and to safeguard against leakage. Trico Fuse Mfg. Co., 2948 No. 5 St., Milwaukee 12, Wis.

For more information—
Circle 13, inside back cover

Welded Alloy Steel Chain

A single branch of the 2-in. size of this alloy chain, for example, has a breaking strength of over ½ million lb, according to the manufacturer. Tensile strength is 125,000 psi after heat treatment, with a minimum elongation of 15 percent and a hardness of 240 to 280 Bhn. McKay Co., McKay Bldg., Pittsburgh 20, Pa.

For more information—
Circle 14, inside back cover

Stainless Steel Linear Bearing

These ball bearings for linear motion will be manufactured for shaft diameters of ¼, ½, ¾, 1, 1½, 2, 2½ and 3 in. This new series of ball bushings will be made to the same basic dimensions as this manufacturer's chrome steel Series "A" bearings. They are said to have the same free rolling characteristics which minimize friction and consequently preclude binding or "chatter". Their very low friction coefficient of 0.002 to 0.004 practically eliminates wear and thus affords lasting precision alignment.

The load-carrying outer sleeve of the bearings and the balls are made from Type 440 stainless steel, which permits them to be hardened to 60 Rc. Retainers and end rings are made of Type 303 stainless. Thomson Industries, Inc., Manhasset, N. Y.

For more information—
Circle 15, inside back cover

Miniature Self-Locking Nuts

This all-metal miniature nut is reported to take up one-half the space of comparable standard anchor nuts and it is also lighter in weight. The locking design employs a simple positive principle wherein the upper threads are made elliptical and highly resilient allowing all threads to carry the actual load, thus eliminating the necessity of an auxiliary locking device. The new nut can be used in temperature ranges up to 550 F. The nuts are now produced in a complete range of sizes from 4-40 to and including ¼-28, in three basic configurations, two lug, one lug and corner types, Kaynar Co., 820 E. 16 St., Los Angeles, Calif.

For more information—
Circle 16, inside back cover

Metal-Backed Nylon Bearings

A nylon-lined, sleeve-type bearing is composed of a metal shell into which is molded an extremely thin lining or

CONTINUED ON PAGE 220

WHEN ROBERT E. PEARY STARTED HIS FIRST POLAR EXPEDITION

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS

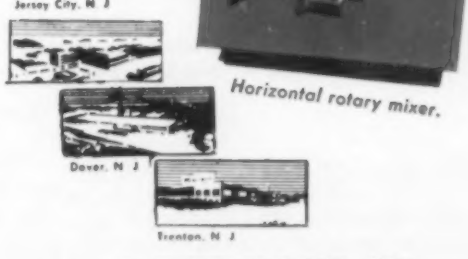
At the time when Peary's heroic Polar explorations were establishing him as an international figure, KOVEN was already a well-known name in the equipment industry.

KOVEN's reputation has grown with the industry, and today — with our economy more than ever geared to fast-paced, low-cost production — leading equipment manufacturers are increasing their efficiency with KOVEN special parts built to their exact requirements — usually more quickly and economically than could be done in their own plants.

If you have a production problem, call or write for a consultation with a KOVEN representative. No obligation.

Send for Bulletin =550.

Our complete modern facilities include: Machine, welding, plate and sheet metal, galvanizing and painting shops. X-ray equipment insures quality control in every KOVEN Individualized Equipment Part.



Horizontal rotary mixer.

L. O. KOVEN & BRO., INC.
154-C Ogden Avenue, Jersey City 7, N. J.
Plants: Jersey City, N. J. • Dover, N. J. • Trenton, N. J.

KOVEN FOR INDIVIDUALIZED EQUIPMENT SINCE 1881

core of nylon of about 0.005 in. thick rigidly anchored to the outer shell. Tolerances are held as closely as ±0.0002 in. for bore, length, outside diameter and concentricity.

The thin lining of nylon not only allows rapid dissipation of heat, but is also said to resist plastic deformation, permitting a higher unit loading than is possible in other nylon bearings. The bearings are made in several types, plain sleeve, with thrust collar, or with dust protector and oil seal as an integral part of the unit. Sizes ranging from as small as $\frac{3}{32}$ in. dia bore to large bearings are available. Nylacore Corp., 305 E. Shore Road, Great Neck, N. Y.

For more information—
Circle 17, inside back cover

Gasket Minimizes Turbulence and Restriction

The inner periphery of this gasket does not extend beyond the ID of the pipe to cause a throttling action. The construction is also said to assure full contact with the pipe flanges. In addition, this design allows the insert to extend to the full depth of the gasket envelope, thereby eliminating an air space.

The envelope is made of chemically inert Teflon, permitting service from −100 F to 482 F, depending upon insert material. Available in all shapes and sizes for a wide variety of applications, the new gaskets are especially recommended for service in glass-lined, porcelain and pyrex equipment, including reactor kettles and pipes, distillation columns and nozzles. Crane Packing Co., Dept. PEN, 1800 Cuyler Ave., Chicago 13, Ill.

For more information—
Circle 18, inside back cover

Hydraulic O-Ring For 300 F

An aircraft quality "O"-ring for hydraulic service is reported to extend the temperature rating of this kind of seal by approximately 37 percent. Temperature range is −65 F to 300 F.

The rubber material for this "O"-ring was developed to meet military specifications MIL-P-5516A and MIL-P-18017. After 50,000 cycles in MIL-O-5606 fluid at 300 F, this new compound showed no appreciable deterioration. All standard sizes are available. Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

For more information—
Circle 19, inside back cover

Torque Converter For Limited Space

This Model C-20 converter is short-coupled, for use where length is a problem. It is available in either ventilated or non-ventilated designs. The main body is a one-piece steel casting, machined to fit engines with SAE flywheel housings.

Standard outside flanges on this new torque converter quickly and economically attach to right-angle drives, transmissions, gear reductions, power take-off hubs or other types of drives. Funk Aircraft Co., Coffeyville, Kan.

For more information—
Circle 20, inside back cover

Heavy Duty 8-in. Diameter Casters

This double ball bearing swivel plate caster has a matching rigid companion, the H-9700 Series. Both swivel and rigid casters are designed for loads up to 1500 lb per caster, and are available in a wide choice of both soft and hard tread wheels. Faultless Caster Corp., 1521 N. Garvin St., Evansville, Ind.

For more information—
Circle 21, inside back cover

Threaded Taper Pin

This threaded end taper pin can be used as an accurate locating or aligning pin, or for mounting units which require occasional removal or replacement. The pin can be quickly and securely inserted into a blind tapered hole. Threads fit standard size nuts, and by turning the nut, or by leverage, jacking action can be applied to remove the pin from the blind hole.

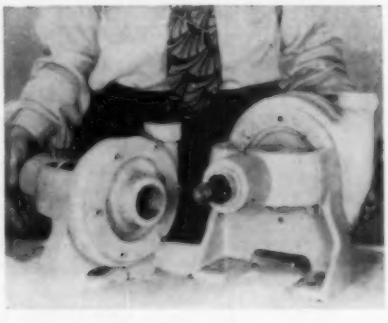
Some current applications are: accurate alignment of motors, pumps, compressors, blowers, other operating units on solid bases, and for aligning component parts of machinery. These pins can be furnished in any length or diameter, accurately tapered $\frac{1}{4}$ in. to the foot, in various metals with turned or centerless ground finishes. John Gillen Co., Inc., 2540 S. 50th Ave., Cicero 50, Ill.

For more information—
Circle 22, inside back cover

Aircraft Drain Valves For All Fuels

These valves conform to all the requirements of AF28208 for fuel drain valves and are suitable for all types of aviation fuels including JP-4, as well as other fluids used in aircraft systems, such as hydraulic fluid, engine oils, water, de-icing fluid, air and gases. All parts are interchangeable. They weigh between 2 and 3 oz and are available in 60 different combinations of inlet and outlet fittings in AN standard types and sizes for tube, pipe and hose connections. Clary Multiplier Corp., San Gabriel, Calif.

For more information—
Circle 23, inside back cover



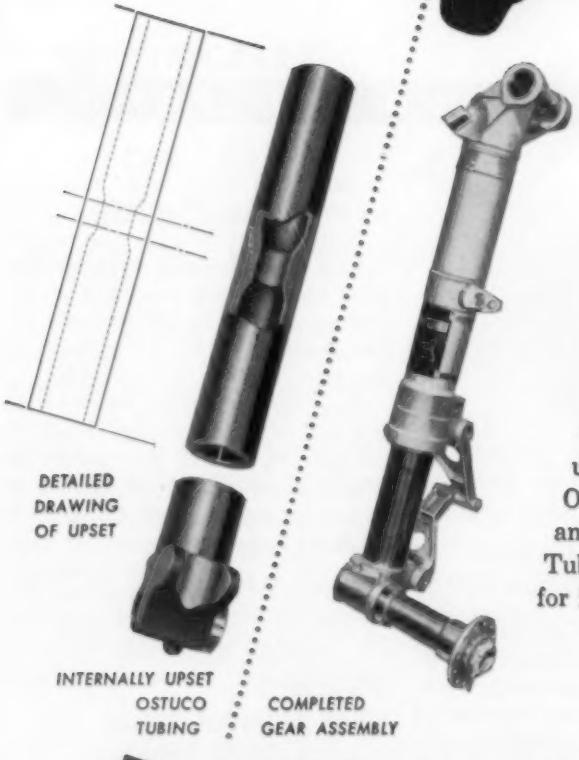
Cast Steel Centrifugal Pumps

A line of cast steel centrifugal pumps has been announced for handling alkaline solutions such as cyanide and caustic and acids such as chromic. Heads of from 10 to 150 ft can be provided

CONTINUED ON PAGE 222

OSTUCO internally upset tubing processes faster

Saves $4.95 per unit



DETAILED DRAWING OF UPSET

INTERNALLY UPSET OSTUCO TUBING

COMPLETED GEAR ASSEMBLY

Landing gears, manufactured by The Cleveland Pneumatic Tool Company for North American Aviation's F-86H, have piston tubes machined from internally upset Ostuco tubing. The upset construction of these *special-quality* Ostuco tube forgings keeps machining to a minimum and permits faster processing. Savings are 25% . . . or $4.95 per unit.

Special-quality Ostuco tubing produces stronger, lighter products . . . better looking products at greater savings. Its uses are practically unlimited. Wherever you use tubing *in any form*, Ostuco's single source service can save you time and money. Write for helpful booklet "Ostuco Tubing," or better still, send us your blueprints for immediate quotation.

OSTUCO SHELBY, OHIO **OSTUCO TUBING**

SEAMLESS AND ELECTRIC WELDED STEEL TUBING —Fabricating and Forging

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Birthplace of the Seamless Steel Tube Industry in America
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EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
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with flows from 10 to 200 gpm. The seal is either a special acid type or "Teflon", and it can be water-cooled or not. Designed for rough chemical service. Complete units and parts can be shipped from stock. Carl Buck & Associates, Essex Fells, N. J.

For more information—
Circle 24, inside back cover

Gage Protector Valve

The shock and wide pressure fluctuations that put strains on the mechanical parts of a gage, causing it to give improper readings or to fail completely, are said to be prohibited by this gage protector. Further, the unit can easily be restored to normal operation if impurities are present in the system. It does not become permanently plugged, but can readily be cleaned.

The unit is available in steel (0-5,000 psi), brass (0-3,000 psi), or stainless steel (0-5,000 psi). Sizes are ¼ and ½ in. NPT. Female threads are used on the gage side, male threads on the pressure side of the line. American Associates, Inc., 1 Baker St., Providence 5, R. I.

For more information—
Circle 25, inside back cover

Molded Knobs and Handles

This group consists of 24 stock molds in different shapes and sizes, said to be designed for use on countless electrical appliances, radios, television, instrument panels, testing equipment, x-ray equipment, refrigerators, stoves. Rogan Brothers, 8009 N. Monticello Ave., Skokie, Ill.

For more information—
Circle 26, inside back cover

Ball-Bearing Trolleys For Conveyors

The Series 500 trolleys are said to be engineered to assure rolling contact with the track at all positions. The wheels are steel; their treads are machined and hardened to give maximum life. The brackets are of forged steel.

Labyrinth seals are normally furnished in the trolleys, but other types can be provided for highly abrasive, very dusty or dirty operating conditions, or where the trolley may be exposed to high temperatures, moisture-laden air or other severe conditions. The trolleys have a large lubricant storage space and a pressure-type grease fitting.

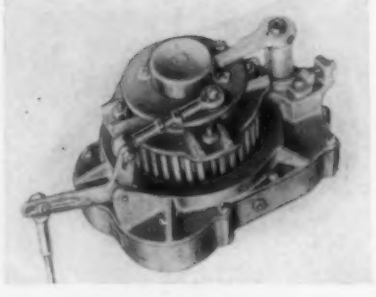
All three sizes of the new trolleys are interchangeable with most other trolleys commonly used with rivetless conveyor chain. The attachments commonly used to adapt the trolleys as carriers for a specific article are also interchangeable.

These trolleys are designed for use on 3, 4 or 6-in. "I"-beams. Trolleys for the 3-in. "I"-beams are for use with No. 348 rivetless chain and have a rated load capacity of 300 lb in monoplane installations; trolleys for 4-in. "I"-beams can be used with No. 458, X458 and 658 rivetless chain and have a rated capacity of 600 lb monoplane. Trolleys for the 6-in. "I"-beams have a capacity of 1,200 lb monoplane and are for use with No. 678 chain.

When these trolleys are used in multiplane installations, their load-carrying capacities may be reduced due to reactions from the chain pull. Four-wheel trolleys are available for use where anticipated loads exceed the capacity of two-wheel trolleys. These trolleys are available in two types: the bolted wheel and bracket assembly, for ease of assembly and disassembly; and riveted, for permanent assembly of wheel and bracket. The bolt, or rivet, is accurately machined and press-fitted in the bracket to provide a rigid assembly and minimize wear. Link-Belt Co., Dept. PR, 307 N. Michigan Ave., Chicago 1, Ill.

For more information—
Circle 27, inside back cover

POWER AND CONTROL



Electro-Mechanical Governor For Voltage, Frequency Regulation

This new governor is an electro-mechanical, load-sensing type, used to control gas or diesel engine-driven generators. It controls the frequency of an engine-driven a-c alternator and it also regulates the voltage of a d-c machine. Both functions are accomplished by controlling the speed of the prime mover.

It is reported that no hydraulic fluids, pumps, plumbing or slip rings are used. Only one element, the rotor, can be considered a moving part.

Normally driven from the engine timing shaft through a set of spur gears which reduce the speed of the rotating element to 150 rpm, adapter pads are used to fit the governor to any type of gas or diesel engine.

In ac, the unit holds frequency to ±½ percent; in dc, voltage is held to ±1 percent. Overall system response is approximately 2 sec, dependent on engine condition. Leach Corp., 4441 Santa Fe Ave., Los Angeles 54, Calif.

For more information—
Circle 28, inside back cover

Planetary Gear Reduced Motor

A sub-miniature, aircraft quality planetary gear reduced motor is ⅞ in. dia and weighs as low as 5 oz. This package consists of a permanent magnet dc motor and precision machined planetary gearing. Overall length varies

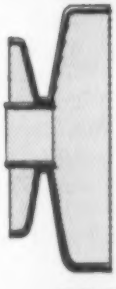
CONTINUED ON PAGE 224

INTRODUCING the new Mercury *Spider* clutch

SPECIFICALLY DEVELOPED FOR ALL GASOLINE ENGINES UP TO 3½ H.P.

INEXPENSIVE . . . engineered to meet the price requirements in the small clutch field. ONE PRICE . . . no price difference in the available ½", ⅝" and ¾" bore sizes. SIMPLE . . . only one moving element—the four friction segments. DEPENDABLE . . . the new spider design with its unique pushing action provides positive release . . . the restraining garter spring has been experience proven as "tops" in its ability to stand up in the field. VERSATILE . . . adaptable to pulley, sprocket or coupling drive. NOISELESS . . . no disturbing chatter. RUGGED . . . DURABLE . . . SERVICEABLE . . . AVAILABLE.

PRICE AND TECHNICAL INFORMATION MAY BE SECURED BY WRITING DIRECT



CROSS SECTION OF HOUSING

Stamped steel . . . copper brazed construction . . . oilite bearing . . . 3X1AB combination pulley.

CROSS SECTION OF ROTOR

Resilient rubber spider . . . finish ground hub . . . long wearing friction segments . . . extremely simple to maintain.

Mercury Clutch Division

AUTOMATIC STEEL PRODUCTS, INC.
1201 CAMDEN AVENUE S. W. • CANTON, OHIO

from 2½ to 3¾ in., depending on speed reduction ratios. Nineteen different standard reduction ratios are available.

Units can be furnished with speed governors for applications requiring close speed control; however, overall length must necessarily be increased. Standard mounting flanges or custom made flanges can be supplied. Separate radio noise filters are also available. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

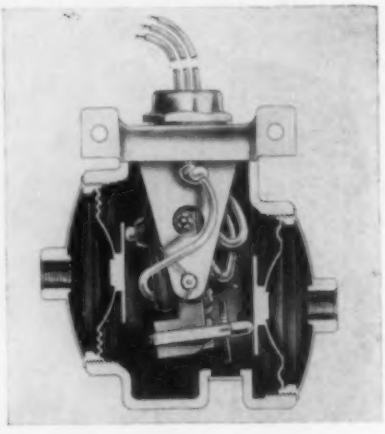
For more information—
Circle 29, inside back cover

Push Button Switch Handles 5 Amp

This switch's snap-action mechanism is reported to reduce arcing and contact wear and provide greater current-carrying capacity than its size would indicate. Moreover, this mechanism provides strongest contact pressure at the point of "break"—thus making it impossible to "tease" the switch on or off contact. The new switch is rated for resistive loads of 5 amp, or inductive loads of 3 amp at 115 v, ac or dc.

Contacts and terminals are of copper with a heavy silver overlay. Either lug-type terminals or wire leads are available as required. The snap-action mechanism, terminals or leads are imbedded in a molded phenolic housing, which seals the unit from dust and moisture. The threaded aluminum bushing swaged to the housing is designed for easy panel mounting in a ½-in. dia hole. Hetherington, Inc., Sharon Hill, Pa.

For more information—
Circle 30, inside back cover



Pressure Difference Switch

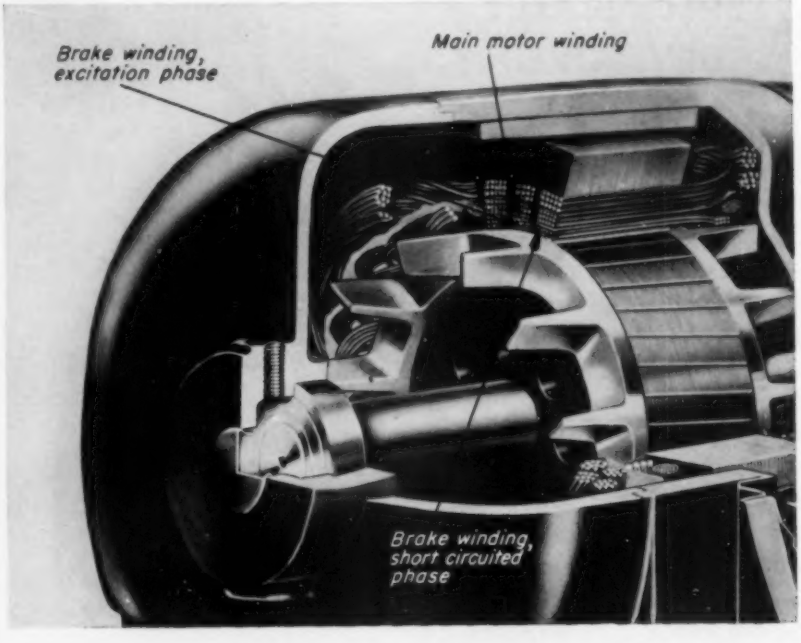
Model 462 is said to sense accurately any pressure difference from 0 and 99 psi between two pressures within the working range of 0.05 to 100 psi. The unit will actuate an elec-

Dynamic Braking Built Into Standard Motors

This a-c dynamic brakemotor is now available up to 30 hp. Larger sizes are being developed. With no moving parts, this braking device is built right into standard frame size, single or polyphase induction motors. A unique multi-polar, two-phase brake winding is super-imposed on the standard stator winding. One phase of the brake winding is connected to a single-phase line during the braking operation. The second phase is permanently short-circuited and is never connected to the line.

The braking action is a two-stage process. First, single-phase current is super-imposed on the excitation phase of the multi-polar brake winding, producing dynamic braking torque down to its synchronous speed. Then, the rotor feeds power into the short-circuited phase of the brake winding continuing the braking action down to zero speed. The braking is smooth and continuous, providing a rolling stop. Since the brake winding is taken out of the circuit at zero speed there is no holding power.

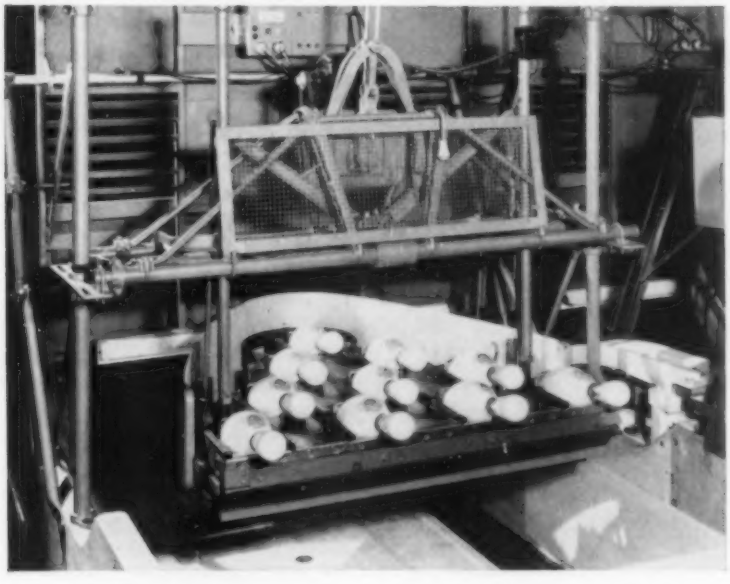
This type of braking can be built into all of this manufacturer's line of standard motors, right-angle and parallel gearmotors and mechanical variable speed drives. There are no limitations as to mountings, enclosures, electrical characteristics, speeds or special mechanical modifications. This new dynamic braking is reported to be particularly well suited for trolley and crane drives, laundry tumblers, printing presses, conveyors, textile machinery, machine tools and special machinery. Master Electric Co., 126-38 Davis Ave., Dayton, Ohio.

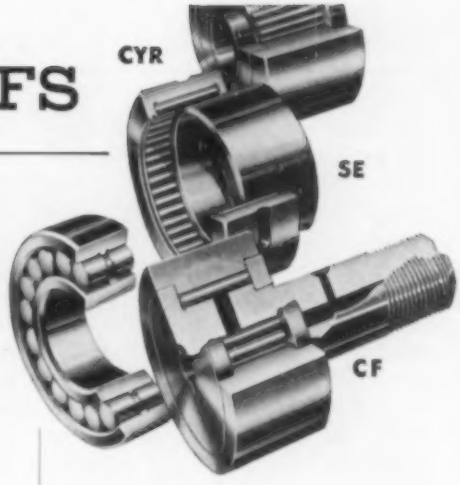


For more information—
Circle 31, inside back cover

CONTINUED ON PAGE 226

McGILL BEARING BRIEFS





CAMROL CF BEARING USED from BEGINNING of PRODUCTION by SCHIELD-BANTAM COMPANY

More than 5,500 cranes and excavators built by Schield Bantam since 1945 use CAMROL CF Bearings in SHIFTING COLLAR vertical swing shafts and drum clutch applications. With maintenance negligible and performance excellent the manufacturer asserts, "Using CAMROL CF Bearings offers an overall price advantage and insures maximum product quality."

CAMROL CF bearings ADD TO SAFETY of 22,000 Brunswick-Balke-Collender semi-automatic pinsetters now in use

When the pinboys "set 'em up in the other alley" a McGill CAMROL Cam Follower helps them do the job without danger to themselves or damage to the pin-setting machine.

Known as the B-10 Semi-Automatic Pinsetter, this machine is a product of The Brunswick-Balke-Collender Company and is in use on 22,000 individual bowling lanes throughout the world.

In these machines the CAMROL CF bearing is used in the safety latch mechanism to lock the cam action and prevent the machine from recycling during pin setting. Used by the company for 4 years, the CAMROL bearing has given no trouble despite the literally millions of cycles these 22,000 machines have been operated.

CAMROL Cam Follower bearings utilize a full complement of small diameter followers with outer race and integral stud and flange custom heat treated for the ultimate in radial and shock load capacity.

Precision tolerances on all grinding surfaces with simplified lubrication minimizes internal wear and increases bearing life. Both starting and running friction are reduced to a minimum.

McGill designed and built the first Cam Follower and used 20 years of experience with thousands of applications to perfect the right Cam Follower for any cam action application.

BEARING SELECTION GUIDE

A revised 140 page Bearing Selection Guide, complete with 30 pages of vital engineering data, has been released by the McGill Manufacturing Co. Ask for Catalog No. 52.

PINES PRESSURE DIE HOLDER PUTS up to 18,000 POUND LOAD on CAMROL CYR BEARING

Pines Engineering Co., Inc., has used the CAMROL CYR Bearing for 6 years in tube bending machines and has never had a failure. The bearing takes the full bending moment in Pines pressure die holders that bend extra heavy pipe in sizes ranging from ¾" to 4" without scratching the tubing.

50th McGILL Anniversary

McGILL design leadership has given you these important developments

★ First full type roller bearing ★ First guided full-type roller bearing ★ First Cam Follower roller bearing ★ First sealed roller bearing

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

tric circuit on increase or decrease of any predetermined pressure difference. Adjustment in the field is accomplished by means of an adjustment ratchet. Tamperproof cover protects setting against accidental disturbance.

This switch operates in any position, simplifying installation, no balancing or levelling being necessary. The functions of the switching or pressure sensing elements are not affected by jarring on mobile installations or by vibrations from pumps and compressors. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

For more information—
Circle 32, inside back cover

Miniature Toggle Switch

Tests are reported to have proved this switch will operate with precise repeatability for well over 100,000 cycles. Other than the beryllium copper spring, all parts of the toggle actuator are made of stainless steel. The patented actuating mechanism assures smooth operation and gives "good feel" detent in both directions.

The switch is available in normally open or normally closed single-pole, single-throw and single-pole, double-throw models. Electrically rated at 5 amp, 125/250 v, ac, or 4 amp, 30 v, dc, resistive. Electro-Snap Switch & Mfg. Co. 4218-30 W. Lake St., Chicago 24, Ill.

For more information—
Circle 33, inside back cover

Hermetically Sealed Contact Relays

These relays differ from conventional relays in that they are asserted to operate on a different principle, which lends itself to sealed contact construction and makes possible fast response, high operating speed, high sensitivity and low capacitance along with low contact resistance. These units are made by enclosing two magnetic cylinders in a sealed envelope and causing the magnetic cylinders to contact each other, thus closing a preset gap between the cylinders.

These relays are characterized by compact construction and a variety of operational characteristics. Noble metal contacting surfaces are welded onto the elements for low contact resistance and high resistance to corrosion. The sealed case can be filled with atmosphere at pressure or with any number of inert or reducing gases, depending on the application. Coils can be supplied for constant current or constant voltage applications, and coil specifications can be varied to meet requirements of sensitivity and operating speed.

Switching rates of these relays are up to 60 cycles per sec. They have average actuating speeds of 1.0 to 2.0 milliseconds. Single and multiple element units (up to 109 contacts) are available, and simultaneous contact closure on multiple element units is within 1 millisecond. Other models having permanent magnets for actuation or biasing, and models having two coils for differential or pulse operation, are available on special order. G. M. Gianmini & Co., Inc., 918 E. Green St., Pasadena, Calif.

For more information—
Circle 34, inside back cover

Push-Button Switch For Hand Tools

An aluminum-covered pushbutton hand switch designed especially for use on punch presses and similar hand-operated equipment is designed to fit into conventional "FS" and "FD" electrical boxes.

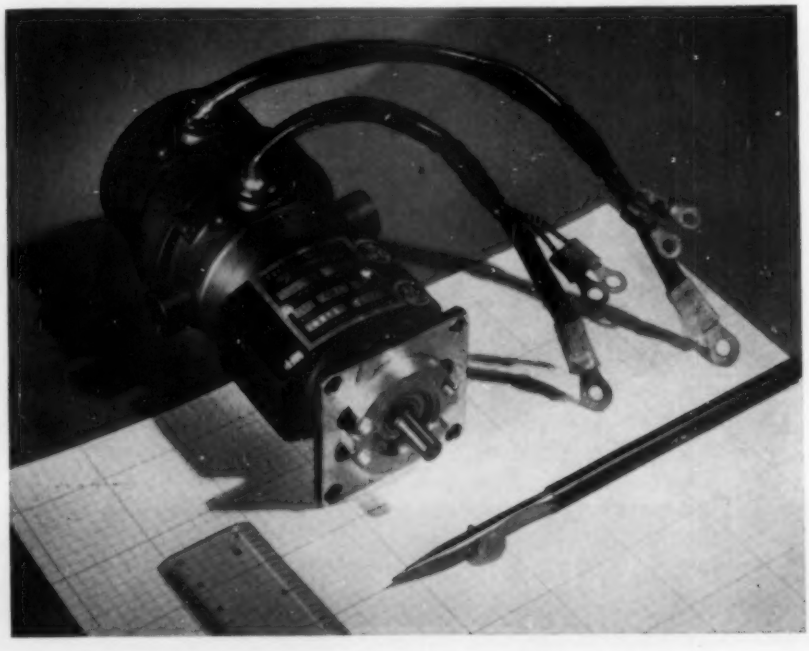
It is 2¼ in. dia, providing a large target for easy manual operation and has a snap-acting spring which gives

Quick-Stopping Motor

This permanent-magnet motor for 28 v, d-c operation has an integral brake separately actuated from 28 v, dc, capable of bringing the armature to a stop from the rated operating speed of 4,500 rpm within one shaft revolution. Designed for continuous-duty applications requiring good speed regulation, the unit supplies a high starting torque of 50 in-oz at 10 amp.

Standard ratings include a total input current, including the 0.25-amp brake current, of 2.5 amp with 40-w load. The dynamic brake torque is 100 in-oz min. Weight is 2.4 lb. Dalmotor Co., 1362 Clay St., Santa Clara, Calif.

For more information—
Circle 35, inside back cover



CONTINUED ON PAGE 228

From Every Standpoint / output · size · efficiency

Chrysler Industrial V-8 Engines are the best power you can install

Chrysler Industrial V-8 Engines are . . . pound for pound . . . the world's most powerful gasoline industrial engines.

To prove that statement—let's look at the facts. In the charts below, we compare Chrysler Ind. 24A V-8 Engine with similarly equipped products of five principal competitors. Information on each competitive engine is based upon factory specifications. Check the Chrysler advantages—each of them is an important factor in the selection of a power plant.

Engine	Horsepower and Piston Displacement	Pounds per Horsepower	Fuel Consumption —pounds per BHP per hour	Horsepower per Cubic Inch Displacement	
Engine A	110 at 2200 RPM 358 cu. in.	(Stripped Engine) 7.38	.54	.307	**CHRYSLER ADVANTAGES OVER ENGINE A** . . . delivers 18 more horsepower . . . weighs 96 pounds less with 24% less weight per horsepower . . . uses 7.5% less fuel at average operating speed . . . delivers 26% more horsepower per cubic inch displacement
Chrysler Model Ind. 24A	128 at 2200 RPM 331 cu. in.	(Stripped Engine) 5.58	.50	.387	
Engine B	104 at 2400 RPM* 330 cu. in.	(Stripped Engine) 6.92	(Information not available)	.315	**CHRYSLER ADVANTAGES OVER ENGINE B** . . . delivers 34 more horsepower . . . weighs 5 pounds less with 25% less weight per horsepower . . . delivers 32% more horsepower per cubic inch displacement
Chrysler Model Ind. 24A	138 at 2400 RPM 331 cu. in.	(Stripped Engine) 5.18	.50	.416	
Engine C	99 at 2200 RPM 320 cu. in.	(Stripped Engine) 7.64	.56	.309	**CHRYSLER ADVANTAGES OVER ENGINE C** . . . delivers 29 more horsepower . . . weighs 60 pounds less with 27% less weight per horsepower . . . uses 10.5% less fuel at average operating speed . . . delivers 25% more horsepower per cubic inch displacement
Chrysler Model Ind. 24A	128 at 2200 RPM 331 cu. in.	(Stripped Engine) 5.58	.50	.387	
Engine D	117 at 2200 RPM 317 cu. in.	6.5**	.50	.369	**CHRYSLER ADVANTAGES OVER ENGINE D** . . . delivers 11 more horsepower . . . weighs 19 pounds more *but* with 6% less weight per horsepower . . . delivers 5% more horsepower per cubic inch displacement
Chrysler Model Ind. 24A	128 at 2200 RPM 331 cu. in.	6.1**	.50	.387	
Engine E	97 at 2200 RPM 372 cu. in.	(Complete Engine) 12.85	.58	.260	**CHRYSLER ADVANTAGES OVER ENGINE E** . . . delivers 31 more horsepower . . . weighs 395 pounds less with 48.7% less weight per horsepower . . . uses 14% less fuel at average operating speed . . . delivers 49% more horsepower per cubic inch displacement
Chrysler Model Ind. 24A	128 at 2200 RPM 331 cu. in.	(Complete Engine) 6.6	.50	.387	

**Information not available at 2200 RPM* ***Complete engine less flywheel housing*

These are not just "paper advantages". They show up on irrigation pumps, in construction and road building equipment, in farm combines, and in many other applications. Thanks to modern engineering, hemispherical-design combustion chamber, short-stroke, low-friction construction, Chrysler offers durability and output in amazingly small, lightweight power packages.

And remember Chrysler Industrial Engines can be factory equipped for operation with gasoline, natural or L-P gas.

See a dealer or write: Dept. 61, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.

CHRYSLER
INDUSTRIAL

ENGINES

Horsepower With A Pedigree

INDUSTRIAL ENGINE DIVISION
CHRYSLER CORPORATION

BETTER THAN THE BEST BUT PRICED WITH THE LOWEST

users a good "feel" of the action.

A neoprene gasket between the base of the switch and the mounting surface and a seal boot between the button and plunger mechanism seal the switching unit from oil and other foreign matter. Flutes and holes in the cover plate are provided to permit the escape of any chips, dirt or oil which may travel inward with the plunger; this is said to prevent binding or jamming.

The switching unit has two double-break circuits—one normally-open and one normally-closed. A snap-action spring causes one set of contacts to break before the other set makes contact. The force transmitted directly from the button and the return force of the button return spring insure positive actuation with each operation of this new unit.

Pilot duty rating of the switch is 6 amp (normal) and 60 amp (inrush) at 125 v, ac; 3 amp normal and 30 amp inrush at 250 v, ac; 1.5 amp normal and 15 amp inrush at 480 v, ac; and 1.2 amp normal and 12 amp inrush at 600 v, ac. Micro Switch, Freeport, Ill.

For more information—
Circle 36, inside back cover

Aircraft Toggle Switches

These toggle switches are approximately 1⅛ in. long, ⅜ in. wide and 1-3/64 in. high, from the bottom of the sleeve to the terminals. The sleeve, which is stated to be both sand and dustproof, is 15/32 in. long.

Steel parts are cadmium plated, while all current-carrying parts are silver plated. All finishes on the slow make and break switches will withstand 100 hr salt spray tests, according to the maker. Arrow-Hart & Hegeman Electric Co., Hartford, Conn.

For more information—
Circle 37, inside back cover

Stackable Switch Components

These switch assemblies consist of a pile-up of various springs, insulators and other parts, available in various arrangements. All such assemblies are made to individual requirements.

Design and material of springs, spacers, contacts and other parts can be varied to meet customer needs. Switchcraft, Inc., 1328 N. Halsted St., Chicago 22, Ill.

For more information—
Circle 38, inside back cover

Open-Type Plug-In Relays

These plug-in relays can be installed, inspected or replaced without disturbing wiring. When used in portable equipment, this type of unit can be removed for protection in transit.

The new plug-in relays can be furnished with standard contact combinations up to 24 arms per relay. Standard contact ratings are 2 amp at 24 v, dc, or 115 v, ac. Bifurcated contacts for extremely low voltage and low current or heavier contacts rated up to 5 amp can be furnished.

Operating voltages available range from 6 to 230, ac or dc. Dimensions, including plug, are 3½ x 1⅛. Height varies with number of contact arms required. Magnecraft Electric Co., 1442-P, W. Van Buren St., Chicago 7, Ill.

For more information—
Circle 39, inside back cover

Ac-Dc Relay With Built-In, Full-Wave Rectifier

Containing four miniature germanium diodes to rectify a-c excitation signals and provide chatter-free d-c switching action, the diodes in this relay are hermetically sealed. They are mounted to allow heat conduction through the can wall. Networks of these relays can be operated directly off the a-c power line, without the need for large d-c rectifiers. These relays can also operate on d-c excitation of either polarity.

A balanced rotating armature is provided which can withstand shock accelerations in excess of 100 G and vibration accelerations in excess of 20 G over the frequency range of 2 to 2000 cycles per sec. A magnetic circuit drives one-pole, two-pole, four-pole, and six-pole ganged contact arms firmly against solid-silver ball contacts. Contact bounce and arcing are held to a minimum, and reduced interference noise meets requirements of MIL-E-6181.

Contact currents of 4 amp with resistive load can be controlled with contact life in excess of 100,000 operations. Higher currents can be handled where shorter contact life is permissible. Contact resistance as low as 0.01 ohm is ideal for signal circuits. Relays can be sealed with dry air or nitrogen. Hi-G Inc., Bradley Field, Windsor Locks, Conn.

For more information—
Circle 40, inside back cover

Time Delay Relay

These adjustable time delay relays are supplied in a 2.2 in. dia aluminum housing 4½ in. long. A large calibrated dial with a positive detent makes rapid and accurate adjustment easy.

Accuracy is 1 percent and one model, adjustable from 2 to 30 sec, is calibrated in 0.2 sec increments. Calibrations are on the perimeter of the dial. Weight of the unit is about 1¼ lb. The unit is for use on 24 to 29 v, dc. Control current is low.

Standard electrical connection is to screw terminals, but solder type can also be supplied. A flange is provided for panel mounting with the dial on the front of the panel. A. W. Haydon Co., Waterbury, Conn.

For more information—
Circle 41, inside back cover

Process Timer Incorporates Percentage Timing

Repeat cycle process timers that operate continuously to turn circuits on and off for constant interval operation are now offered with the added advantage of percentage timing. Percentage selection is said to provide constant accuracy in repeated operation and reduction of strain on electrical components. The percentage

CONTINUED ON PAGE 230

Specify

GITS *Unit* SEAL

Result:

Economy

"Economy. . . counts not in savings but in selection."—*Edmund Burke*

Economy through Efficiency

Gits Unit Seal proves itself in dependable performance over a wide range of operating conditions—including extra-high speed, heat and pressure applications. Operation at peak efficiency always means dollars-and-cents savings.

Economy through Adaptability and Versatility

Gits Unit Seal fits many applications as a standardized item actually carried in stock. You harness the savings of mass production to your own specific needs. Gits Unit Seal already has wide application in the following fields: Washing Machines, Disposal Units, Gear Motors, Speed Reducers, Aircraft Turbine Pumps, Accessory Drive Units, Jet Propulsion Units, Electrical Power Equipment, Automotive Accessories, Business Machines, Standard and Special Machine Tools.

Economy through Long Life

Gits Unit Seal is designed for maximum life in any recommended application. Here's the real "proof of the pudding" in saving money.

Write Today For FREE Illustrated Brochure, or send us your seal problem. Our experienced engineering staff is at your service.

*Cartridge Seal . . . requiring only 25% more space than lip-type seals.

GITS BROS. MFG. CO.

1838 S. Kilbourn Avenue Chicago 23, Illinois

selected to maintain a uniform temperature is set in the same manner as for any of its other applications. A simple turning of the knobbed pointer is the only adjustment necessary.

The new unit has a time cycle of from 15 sec to 24 hr, with a range of adjustability for "on" or "off" periods up to 94 percent. It is applicable for use on radiant type heaters, fire controls, mixing machinery, testing equipment, fans. The timer is equipped with visible dial, snap-action switch with silver contacts, synchronous motor. Dimensions are: 5 in. high, 3 in. wide, 3 in. deep. Zenith Electric Co., Dept. PEN, 152 W. Walton St., Chicago 10, Ill.

For more information—
Circle 42, inside back cover

Electronic Pilot Relay

This relay is reported to be able to control large current and power values with a current flow of as little as 2 microamperes. A cold cathode triode tube provides greater sensitivity and no warm-up period is required. Case dimensions are 7 in. height, 6 in. width, 4 in. depth. Weight is 3 lb, 2 oz. Industrial Electronic Controls Co., 2271 E. 14 St., Brooklyn 29, N. Y.

For more information—
Circle 43, inside back cover

Side Mounting Miniature Connectors

The countersunk side mounting hole and narrow width of these connectors permit exceptionally flat mounting. This is said to be proving effective in solving circuit terminal problems in apparatus where space is limited, or where unusual design prohibits conventional connector mounting.

Contacts are rated at 5 amp, use No. 20 AWG wire and are precision machined and gold-plated over silver for low contact resistance, prevention of corrosion and ease of soldering. Mineral-filled Melamine bodies provide high dielectric strength and arc resistance. Available with either two or four contacts, the reversed pin and socket assembly provides positive polarization. Dimensions are: 7/16 in. high, 1-1/32 in. max overall engaged length, $\frac{1}{8}$ in. wide (two-contact type) and $\frac{1}{4}$ in. wide (four-contact type).

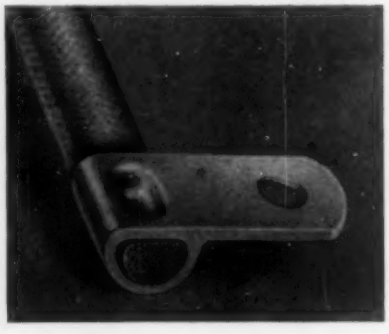
Minimum voltage breakdown at sea level is 2250 v, dc; at 60,000 ft. altitude, 700 v, dc. Weight of two-contact connector is 0.03 oz, four-contact connector, 0.06 oz. Winchester Electronics, Inc., Dept. K, Norwalk, Conn.

For more information—
Circle 44, inside back cover

Solderless Connecting Lugs

Available in 6 sizes, these lugs are produced from 100 percent pure electrolytic copper. Their two-hole collar construction is said to provide secure mountings where close spacing must be maintained and where connectors must not turn and come into contact with each other. Ilsco Corp., Cincinnati 27, Ohio.

For more information—
Circle 45, inside back cover



Flag-Type, Compression-Installed Terminal

Extruded, compression-installed terminals for aircraft wiring are designed for side entrance installations, where space requirements prevent the use of straight or right-angle type lugs. Of tin-plated copper, these terminals are available for flexible copper cable sizes No. 8 through 2/0. Tin-plated, heavy-wall aluminum connectors, designed to withstand high ambient temperatures and severe overloads are available for aluminum aircraft cable sizes No. 8 through 4/0. Burndy Engineering Co., Inc., Norwalk, Conn.

For more information—
Circle 46, inside back cover

Miniature Panel Meters

A line of $1\frac{1}{2}$ in. ruggedized miniature panel meters, designed to meet specification MIL-M-10304, is now being produced. Designed for a dielectric strength of 1500 v, rms, Model 163 is magnetically shielded, and has combination solder lug and stud terminals. The lance-type pointer and the three cardinal points of the scale are self-luminous. Zero of the scales is at the left. Initial accuracy is within ±3 percent of full scale deflection. Weight is 4.2 oz. International Instruments, Inc., New Haven, Conn.

For more information—
Circle 47, inside back cover

Digital Voltmeter

With a revolving three-digit counter, this voltmeter affords direct readings of voltage, current or resistance without the necessity for interpolation or the possibility of errors caused by parallax or reading of the wrong scale. The dial is also equipped with illuminated, automatic decimal point and polarity sign as further aids to quick, accurate readings.

Sensitivity ranges for the Model 615 are from 1 millivolt to 1,000 v and from 1 kilowatt to ten meg, with an accuracy rating of 1 percent (on dc, and 2 percent on ac). Hycon Mfg. Co., 2961 E. Colorado St., Pasadena 8, Calif.

For more information—
Circle 48, inside back cover

D-c Braking Controller

A d-c braking controller no larger than a combination linestarter is available in two sizes of enclosures for braking standard induction motors from $\frac{1}{4}$ to 25 hp. The controller is said to provide braking torques of as

CONTINUED ON PAGE 232

more than 15,000,000 contacts without 1 cent for repairs...

here's the limit switch that spells electrical control dependability in any language

Send for Bulletin EM-51 which shows various types of Snap-Lock Limit Switches available, design features, specifications, wiring diagrams, ordering data — and other National Acme electrical components and controls.

Proven stamina under all kinds of operating requirements (some installations requiring more than 400 contacts per minute) has made National Acme SNAP-LOCK Limit Switches a top-heavy favorite with both design and production engineers.

Mechanical simplicity and ruggedness are the reasons why Snap-Locks have proven an outstanding success in thousands of heavy duty equipment installations. The record shows that in many such cases, they have stood up under more than 15,000,000 contacts.

Built in a variety of sizes and designs including water resistant and special purpose types.

Ask us to assist you in designing these trouble-free switches into your equipment

ELECTRICAL MANUFACTURING DIVISION

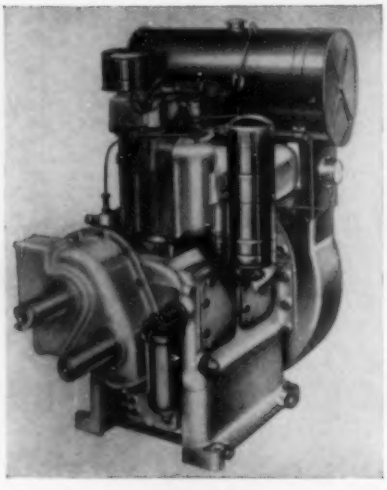
The NATIONAL ACME COMPANY

170 EAST 131st STREET • CLEVELAND 8, OHIO

much as eight times full load running torque.

Operated from a single "start-stop" pushbutton, the new controller requires no adjustment after initial installation. Its main components are a selenium rectifier, contactors, transformer, and a timing circuit. Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

For more information—
Circle 49, inside back cover



Air-Cooled Engines of One and Two Cylinders

These are air-cooled engines, made in single-cylinder and twin-cylinder models, of the four-stroke type, by Armstrong Siddeley Motors, Ltd., Coventry, England. The single-cylinder engine develops 6 to 11 hp at 1000 to 1800 rpm and the twin-cylinder develops 14 to 22 hp at 1000 to 1800 rpm.

Drives at full engine speed are usually taken from the front end of the crankshaft, but can be taken from the flywheel end of the engine by use of an adapter. Drives at half speed can be taken from the camshaft which extends through the front cover and is specially designed to take the full load output of the engine.

Electric starting equipment is provided as required, but use of the standard hand-crank allows easy cold starting. An engine may be hand-started from the flywheel end, if necessary, by use of a special adapter. The engines have a bore and stroke of 4¼ x 4¼ in., and a compression ratio of 15 to 1. National Supply Co., 2 Gateway Center, Pittsburgh, Pa.

For more information—
Circle 50, inside back cover

Unmounted Motor Speed Controls

Stripped down models of a line of motor speed controls are available in all sizes from 1/15 to 1½ hp. All parts except the speed control element are mounted on a metal chassis with connections brought out to a terminal strip. Various circuit arrangements can be used depending on the need for reversing, dynamic braking and other factors. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

For more information—
Circle 51, inside back cover

Two-Wire Thermocouple In Stainless Tubing

This device is available with either of two types of terminal heads: an open head assembly or a screw-cover head. The latter comes in two sizes. The stainless steel protecting tube is expected to double the life of the new thermocouples. Accuracy of the new device is rated at ±5 F over a range from 0 to 1000 F.

Lengths of the thermocouples range from 6 to 60 in. Lengths of 35 ft are available on a special basis. Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

For more information—
Circle 52, inside back cover

Totally-Enclosed Dial Rheostat

A hand-operated rheostat, rated at 9 amp, 115 v, ac-dc, 75 to 300 ohm, in continuous service, allows step control for low-current applications in electronic, industrial, aeronautical, and consumer equipment. An integral switch turns the unit off automatically when the pointer dial is turned to "off." The dial allows selection of 40 different resistances.

Measuring 3⅛ in. long x 2⅝ in. wide, the integral die-cast aluminum case is finished to customer requirements and mounted on rubber pads for table-top operation. The core is molded of highest quality ceramic materials and is continuously wound with special alloy resistance wire. Colbert Die Cast Co., 5416 Tweedy Blvd., South Gate, Calif.

For more information—
Circle 53, inside back cover

V-Belt Fasteners

With these fasteners, V-belts can be made up in any length to fit any drive. The fastened belts are said to perform exceptionally well on single as well as multiple drives. The device's bushing is made of nylon. They are furnished in sizes for A, B, C and D belts. Flexible Steel Lacing Co., 4607 Lexington St., Chicago 4, Ill.

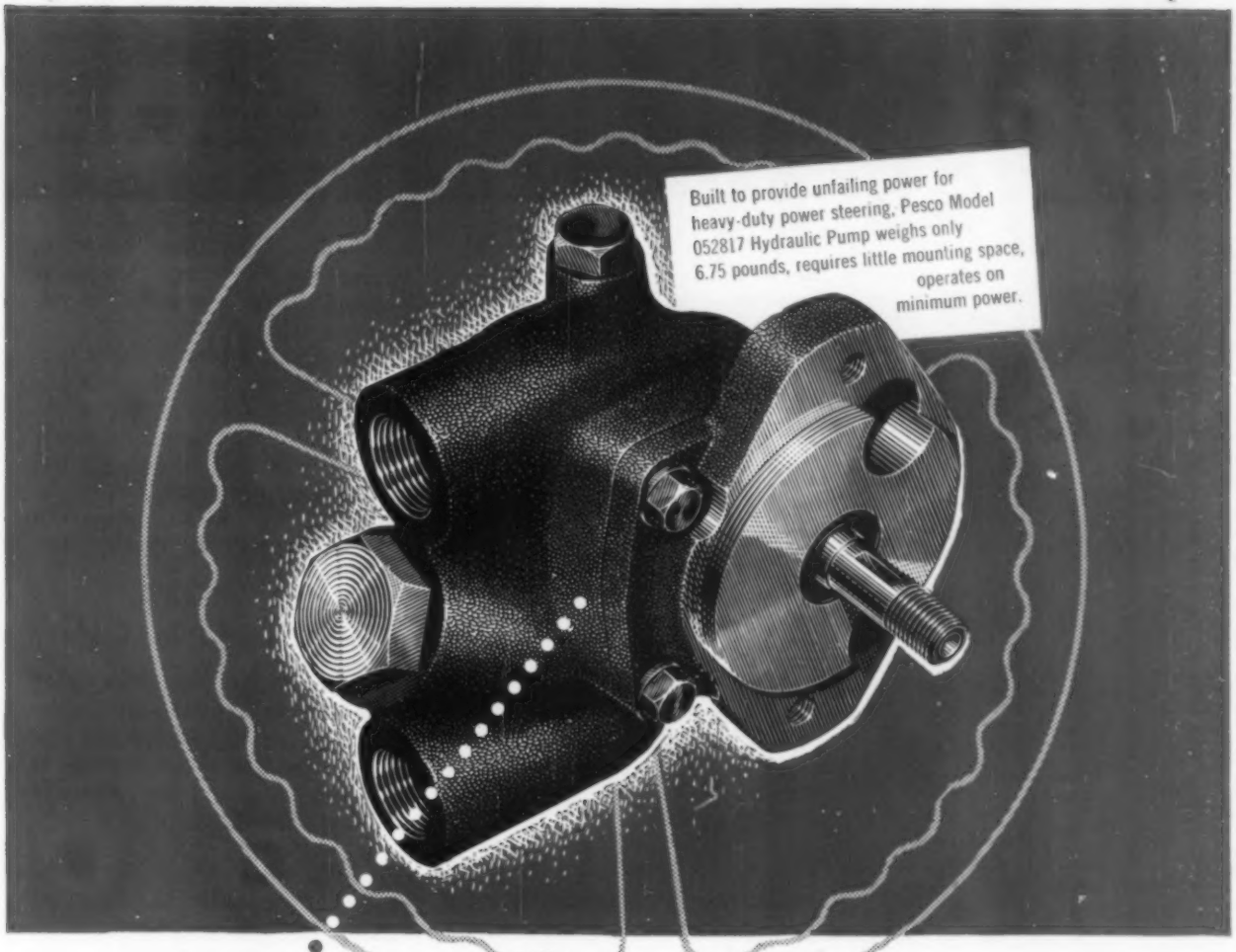
For more information—
Circle 54, inside back cover

Heat Regulator For Changes of 0.005 C

A mercury-type regulator for temperature circuits in viscosity baths and similar operations is said to have an accuracy and sensitivity hitherto unavailable even in fixed-contact thermostats. Under favorable conditions, constant temperature baths are said to be controlled within ±0.002 C.

This device has an improved reservoir for displaced mercury, used when making rough or preliminary adjustments, and a variable electrode with a magnetically controlled micrometer for fine adjustments. The rough adjustment sets the mercury level for a new operating temperature by the typical heating and cooling process. From the rough operating temperature thus reached, fine adjustment to the precise operating temperature is made by merely twisting the magnetic control. As the magnet turns, it causes

CONTINUED ON PAGE 234


Built to provide unfailing power for heavy-duty power steering, Pesco Model 052817 Hydraulic Pump weighs only 6.75 pounds, requires little mounting space, operates on minimum power.

Better steering starts here!

Improved power steering for all types of heavy-duty vehicles, both over-the-road and off-the-road units, starts with Pesco's Hydraulic Steering Pump. On trucks, tractors and construction equipment, this Pesco-designed pump provides unfaltering hydraulic power regardless of operating conditions.

This engine-driven, positive-displacement gear pump features: (1) "Pressure loaded" bearings which automatically adjust for wear assuring sustained new pump performance, (2) minimum power requirements, (3) minimum size and weight, (4) self-lubrication by fluid pumped and (5) a standard pressure relief setting of 750 psi. Operating at 750 psi and 750 rpm, it delivers 3.0 gallons per minute.

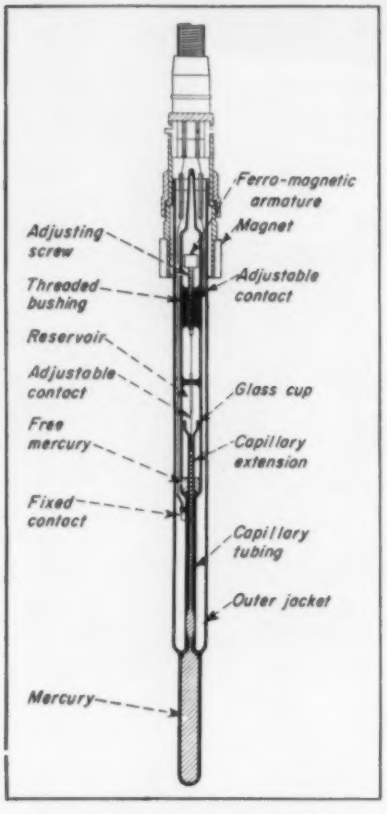
Pesco creative engineering produced this pump—and it can produce a pump designed for your exact needs. The experience and "know-how" of Pesco engineers may produce a better and more profitable answer to your hydraulic power problem. This engineering service is available to you . . . and we think you will like the results you get.

Pesco engineers will be glad to supply complete technical information. Operating models are available for testing on your equipment. Call or write: PESCO, 24700 North Miles Road, Bedford, Ohio.

engineering Pesco production
PRODUCTS DIVISION

AGRICULTURAL INDUSTRIAL AIRCRAFT AUTOMOTIVE CONSTRUCTION EARTH MOVING

BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO



an armature to rotate through a micrometer which controls the position of the variable electrode. The variable electrode is moved up or down as desired, and the contacts are set for the circuit to break at the precise operating temperature desired. It is said that changes as small as 0.005 C can be made with the magnetic control.

The regulator operates within a temperature range of −35 C to 300 C. Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.

For more information—
Circle 55, inside back cover

Wide Range Accelerometer

A barium titanate accelerometer, representing a modified version of a NBS design, has a resonant frequency of 100 kc, plus a useful frequency range of 10 to 40,000 cycles per sec. Sensitivity of Model A 450 is 0.25 mv/g, with a capacitance of 500 mmf or higher without cable. Maximum sensitivity is perpendicular to the mounting, and lateral sensitivity is less than 10 percent.

Temperature range is less than ±10 percent variation in sensitivity from −40 C to −90 C, and acceleration range measures from 50 g to 50,000 g. Size of the unit is ½ in. hex by 1½ in. length; weight is approximately 1¼ oz. Gulton Mfg. Corp., Metuchen, N. J.

For more information—
Circle 56, inside back cover

Electrical Cable Reel

This continuous, heavy duty cable reel with a retractable spring speeds up pay-out and take-up of electrical power supply cables on hoists, cranes and mobile equipment, reportedly protecting the cables from tangling and unnecessary wear. The unit is available with either a plain or pivot base. The pivot base allows the reel to swivel over an arc of 330 deg on self-lubricating bearings. The spring housing permits use of a variety of springs, making this reel adaptable to a balance reel, hose reel or similar applications. The approximate weight is 25 lb. Operation is based on 30 amp, 600 v, ac, 300 v, dc, 1 to 8 conductor collector rings. Industrial Electrical Works, 1503 Chicago St., Omaha, Nebr.

For more information—
Circle 57, inside back cover

Circuit Breaker for 400 Amp

This circuit breaker, according to the manufacturer, is the first of the 400-amp frame size to be built. It is designed to bridge the gap between the present 225-amp frame, molded case circuit breaker and the 600-amp model.

This new unit measures 9 in. wide, 15½ in. high and 5½ in. deep, including handle. It is designed for use in panelboards, switchboards, motor controls, bus duct plugs and individual enclosures.

A thermal-magnetic circuit breaker with quick-make, quick-break operating mechanism, interchangeable trip units provide continuous rating versatility from 125 to 400 amp. Common trip operation is retained and an overcurrent on any pole kicks out all poles simultaneously.

Extra auxiliary devices—shunt trips, undervoltage trips, auxiliary and alarm switches—can be mounted inside the breaker case. The new breaker is factory-calibrated and sealed to prevent tampering.

The unit is available in ratings from 125 to 400 amp, either two or three-pole, for 600 v, ac, or 250 v, dc, 25,000 amp max interrupting capacity. I-T-E Circuit Breaker Co., 19 and Hamilton St., Philadelphia 30, Pa.

For more information—
Circle 58, inside back cover

Sub-Miniature Pilot Lights

These pilot light assemblies mount in a single ⅛ in. clearance hole and require no insulating mountings. The socket, lamp, and all connections are well-insulated from the mounting bushing. Phenolic material provides the insulation.

Two terminals are provided for the electrical connections. The mounting bushing may be grounded to the panel, and the integral insulation of the pilot light completely isolates the lamp circuit from ground.

This series is designed to employ any of the five standard midget flanged base incandescent lamps of 1.3, 2.7, 6.0, 14.0 and 28.0 v.

"Omnidirectional" visibility is said to be afforded by the stovepipe-shaped cap of high heat plastic, into which the bulb extends so that its glow is visible from all angles. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.

For more information—
Circle 59, inside back cover

Amplifier For Servos

Designed for remote control devices, computers, positioning servos and any two-phase motor, these magnetic amplifiers are said to provide precision variable phase power control with a minimum of size and weight. In many applications it is claimed that they can eliminate use of a preamplifier. They operate on a smaller signal, and

CONTINUED ON PAGE 236

ALLENPOINT SET SCREWS Proved 5 Ways Better

Tested by a prominent independent laboratory against standard cup point and serrated point set screws, Allenpoint socket screws topped them all. In every test — carefully set up to simulate actual installations — Allenpoints outperformed and outlasted competing set screws.

BETTER *Cup Point Pattern*

Allenpoints make the all-important full circle pattern when tightened up to *ordinary* pressure — the normal force exerted to tighten a socket screw by hand.

BETTER *Resistance to Rotation*

Deep driven Allenpoints hold longer under increasing torsional strain than any other set screw tested.

BETTER *Cup Point Depth*

The deeper they drive the tighter they hold. Allenpoints — again at average wrenching pressure — penetrate smoothly and deeply with no gouging, no cutting action.

BETTER *Resistance to Longitudinal Thrust*

Tighten an Allenpoint held collar to a shaft with a wrenching pressure of only 150 inch pounds. It will take 1200 lbs. of longitudinal thrust to start that collar along the shaft. No pipe extension, no twisted wrenches to get effective tightening pressure. Allenpoints hold tightly at average *hand wrenching* pressure.

BETTER *at Withstanding Vibration*

Long after other set screws loosen their grip, Allenpoints hold firm under repeated vibration.

Write our Advertising Department for a detailed, technical brochure on these comparative tests. It's got the facts on the Allenpoint story.

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Hartford 2, Connecticut, U. S. A.

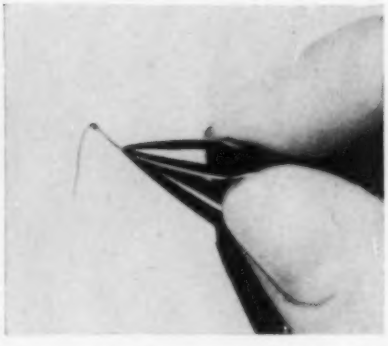
Sold Only Through Leading Industrial Distributors.

Specify Genuine Allenpoint Set Screws.

incorporate high-temperature germanium diodes for higher operating temperatures.

Six standard models are available—each can be adapted to meet individual requirements. Keystone Products Co., 904 23 St., Union City 2, N. J.

For more information—Circle 60, inside back cover



Smallest Commercial Thermistor With High Speed Response

This thermistor is a tiny, glass-coated ceramic element less than 0.018 in. dia with 0.001 in. dia platinum alloy leads. Thermistors of this size previously available are said to have been rated for a maximum continuous temperature of 150 C. The new type is rated at 300 C where it is extremely stable, and is useful even to 400 C with good stability.

The thermal time constant of this tiny sensing unit is only 1 sec, even in still air, and even faster in liquids. The new thermistor can be heated by 1 milliwatt of electrical power more than 10 C above the ambient temperature in still air. Thermistor Corp. of America, Metuchen, N. J.

For more information—Circle 61, inside back cover

Transistor for Development and Experimentation

According to the manufacturer, shelf life and exposure to full rated temperature will not change the characteristics of this transistor. Glass-to-metal seals and resistance welded seams hermetically seal this component, which was developed for use in audio and supersonic frequency stages. It has a maximum frequency cutoff at 2.5 megacycles with the design center at 1.0 megacycle.

Alpha design center of the new transistor is 0.95, while the maximum collector voltage is −20 v and the maximum junction temperature is specified at 60 C. The transistor is capable of dissipating 50 milliwatts in 25 C free air. General Electric Co., Syracuse, N. Y.

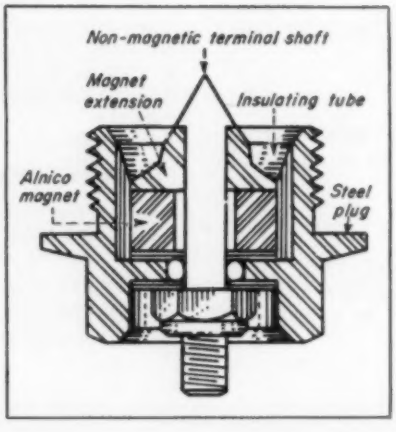
For more information—Circle 62, inside back cover

High Speed Sampling Switch

Typical specifications for this switch are 60 contacts, 30 channel, one pole, and sampling rates up to 60 rps. Multiple stacked pole designs as well as variations in number and arrangement of contacts are readily available.

Dimensions are $2\frac{3}{8}$ in. dia, $1\frac{7}{16}$ in. long excluding terminals, hub and shaft. Hub is $\frac{3}{4}$ in. dia and $\frac{1}{2}$ in. long. General Devices, Inc., P. O. Box 253, Princeton, N. J.

For more information—Circle 63, inside back cover



Magnetic Chip Detector

A magnetic detector designed to act as a warning signal when chips collect inside an engine or gear case was originally designed for use in aircraft engines. Its manufacturer states that the device may be installed in any engine sump or gear case.

A permanent magnet in the body of the detector attracts ferrous metal present in the lubricant. At regular intervals the detector may be checked by applying an indicator lamp (flash light battery and lamp arrangement) to the chip detector. If there are enough metal particles accumulated to bridge the gap between the insulated magnet extension and the grounded body of the detector, the signal lamp will light. Spacing between the magnet extension and the detector body can be varied to provide the proper gap for various applications. Lisle Corp., Clarinda, Iowa.

For more information—Circle 64, inside back cover

Sub-Miniature Encapsulated Resistor

This unit is $\frac{1}{4}$ in. dia and $\frac{5}{8}$ in. long and can be supplied with up to 400,000 ohm max resistance. Mounting is by radial leads and power rating is 0.1 w.

This resistor is made in accordance with MIL-R-93A specifications, meets all humidity requirements and can be used from −55 C to 125 C. It is available in accuracies to ± 0.05 percent and can be supplied with any type resistance wire depending upon the temperature coefficient required. Daven Co., Dept. RD, 191 Central Ave., Newark 4, N. J.

For more information—Circle 65, inside back cover

Differential Pressure Potentiometer

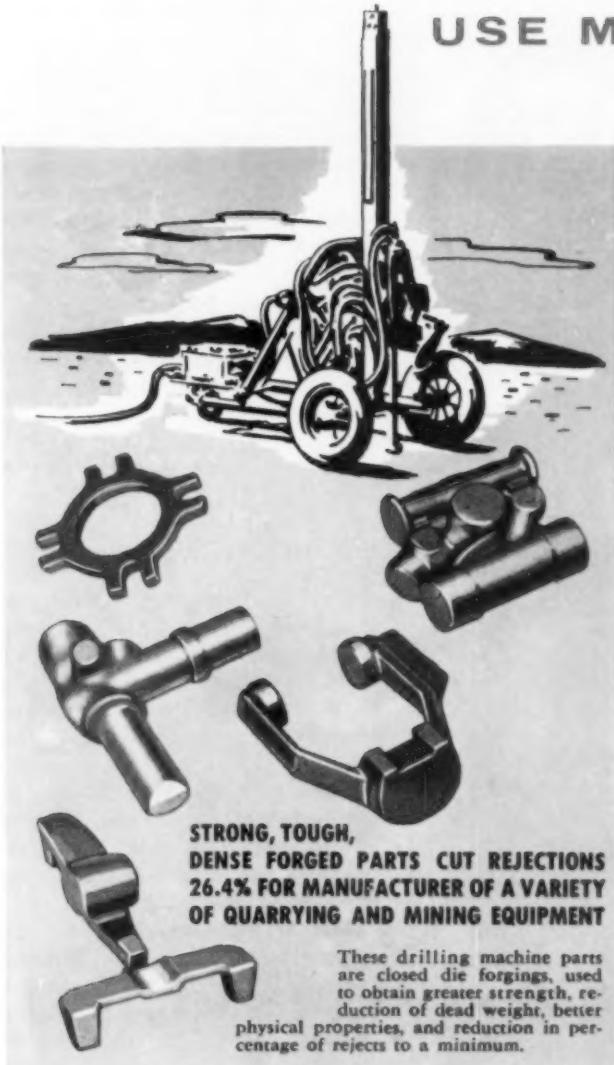
Engineered to withstand missile and rocket applications, this potentiometer measures the difference between pressures applied to the two pressure ports. Typical applications are the measurement of fuel tank pressure, airspeed and pressure drop across an orifice. The unit has an electrical contact arm with a counter-balanced linkage that pivots in a miniature ball-bearing assembly, providing what is

CONTINUED ON PAGE 238

USE MORE FORGINGS

get more Cost Reductions at the point of assembly

A thorough "going-over" of each part of a product or mechanism to consider whether it can be or should be more efficiently produced will inevitably yield some worthwhile reductions in cost at the point of assembly. This process of examining each component may be accomplished in less time and with less effort than would first appear with the aid of Drop Forging "Problem Parts Charts" for design engineers, production executives, metallurgists and purchasing agents. These charts utilized along with the experienced skill of a forging engineer working with one or more members of a production team often reveal cost reducing possibilities heretofore undiscovered. Ask a forging engineer for a complete set of Problem Parts Charts.



STRONG, TOUGH, DENSE FORGED PARTS CUT REJECTIONS 26.4% FOR MANUFACTURER OF A VARIETY OF QUARRYING AND MINING EQUIPMENT

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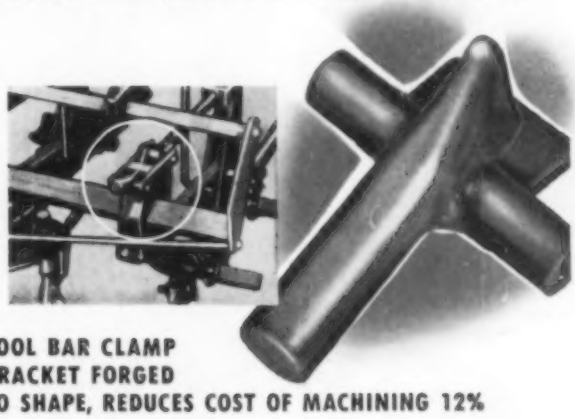

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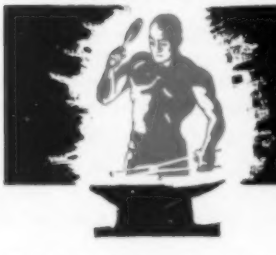
This book tells why forgings are used for the toughest work loads. Engineering, production and economic advantages obtainable with closed die forgings are presented in this reference book on forgings. Write for copy today or attach coupon to your business letterhead.

A New Movie entitled, "Forging in Closed Dies," reveals all aspects of the closed die forging process of forming parts. Represents over ten years of planning and research. It is available for industrial training, sales training, instruction in engineering and metallurgy courses at the college level, and for technical, industrial and engineering societies. Write for information about loan of film without cost.



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605 Hanna Bldg., Cleveland 15, Ohio

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incorporate high-temperature germanium diodes for higher operating temperatures.

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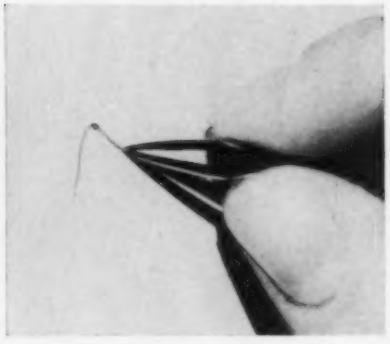

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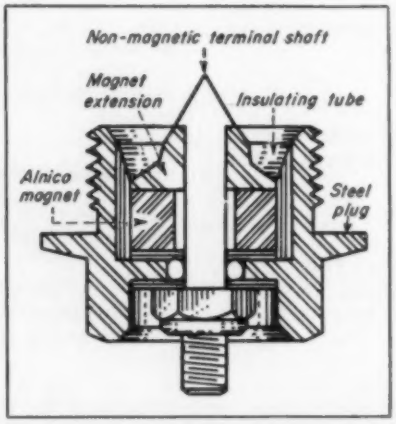

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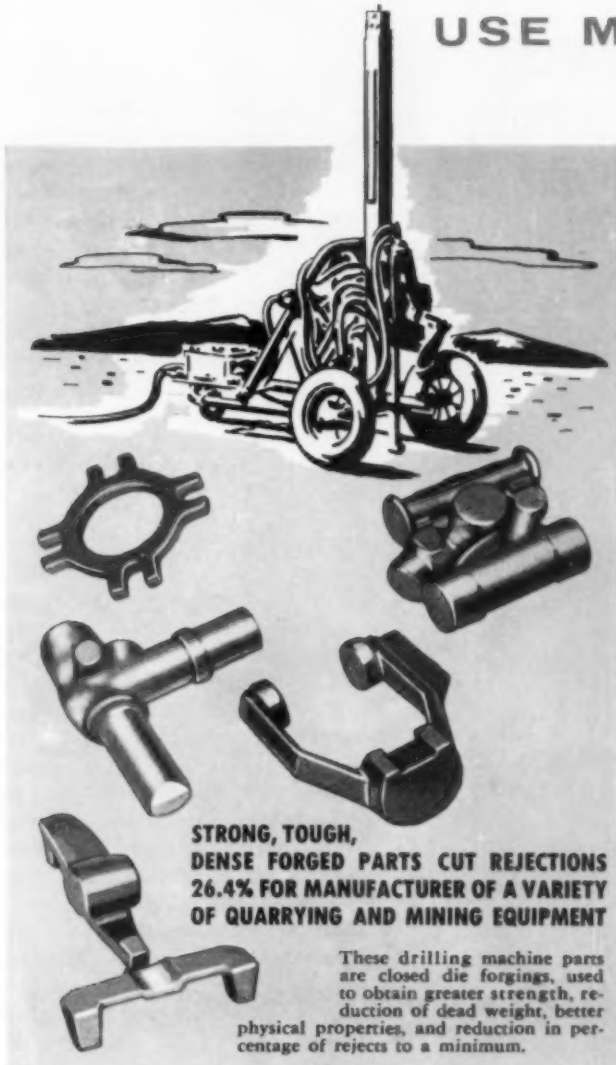

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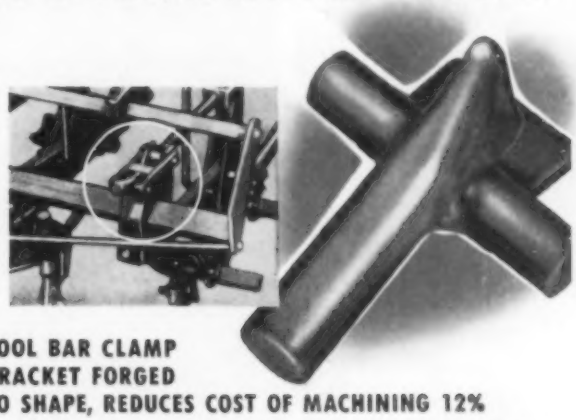

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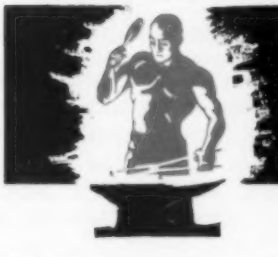
A New Movie entitled, "Forging in Closed Dies," reveals all aspects of the closed die forging process of forming parts. Represents over ten years of planning and research. It is available for industrial training, sales training, instruction in engineering and metallurgy courses at the college level, and for technical, industrial and engineering societies. Write for information about loan of film without cost.



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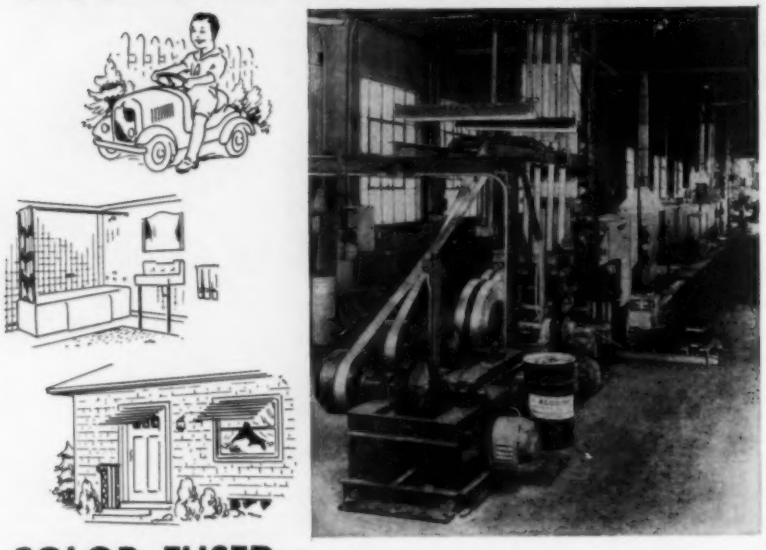

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Arrow Metal Products Corp. of Haskell, N.J. is the largest producer of pre-coated, color fused aluminum coil. Alodizing with "Alodine" has made possible its beautiful, durable, baked enamel finish, as well as its "Porcenamel" thermo-set plastic finish for aluminum coil, and pressed and formed aluminum parts.

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asserted to be accurate and dependable performance even during conditions of extreme temperature, shock, vibration and acceleration.

Performance characteristics include resolution of 0.25 to 0.50 percent for resistances from 1000 to 10,000 ohm. Optimum linearity and repeatability with minimum hysteresis are assured by a specially developed beryllium copper diaphragm-type bellows. Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

For more information—
Circle 66, inside back cover

Miniature Potentiometer

A low-torque potentiometer less than 1 in. dia, yet reportedly as accurate as standard units up to several times its size, is designed for either linear or non-linear output functions.

Accuracy is ± 0.1 percent for linear and 0.25 percent for sine or similar function. This instrument may be obtained with a resistance value of 200 up to 50,000 ohm. Non-linear functions and ranges are dependent on individual requirements.

Maximum linear and functional resolution is 0.034 percent. Starting torque is 0.05 in-oz max for one section, 0.03 in-oz for each additional section. A unique heat-dissipating design permits the Model 36000 to function accurately over a temperature range off −50 C to 90 C. Weight is 1 oz for one section, 0.25 oz for each additional section. It has been constructed to withstand vibration of 10G to 500 cycles per sec, shock to 60G. Mechanical rotation is continuous; electrical rotation is 358 deg max (360 deg continuous on precious metal wiping surface). Gyromechanisms, Inc., Halesite, N. Y.

For more information—
Circle 67, inside back cover

Potentiometer for Close Servo Followup Loops

This potentiometer provides a linear resistance change with rotation rather than an incremental change with rotation as found in helically wound types. When used in servomechanisms where high accuracy is

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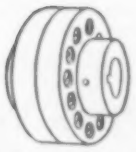
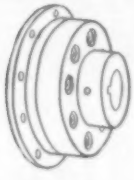
answers to your direct drive problems

Ajax Flexible Couplings are made in a wide range of sizes and capacities to handle alignment problems on direct-driven machines. Hundreds of thousands in use. Performance proven over 30 years. Write for catalog.

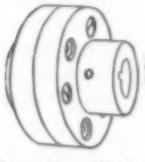


Ajax Type A Semi-Steel and Type S Forged Steel Couplings

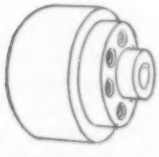
Ajax Type SP Shear Pin Coupling



Ajax Type BO Bolt-On Coupling

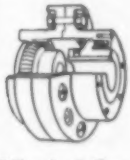


Ajax Type M Mill Motor Coupling



Ajax Type BD Brake Drum Coupling

Ajax No. 423-523 Couplings for full motor speeds



Ajax Dihedral Coupling

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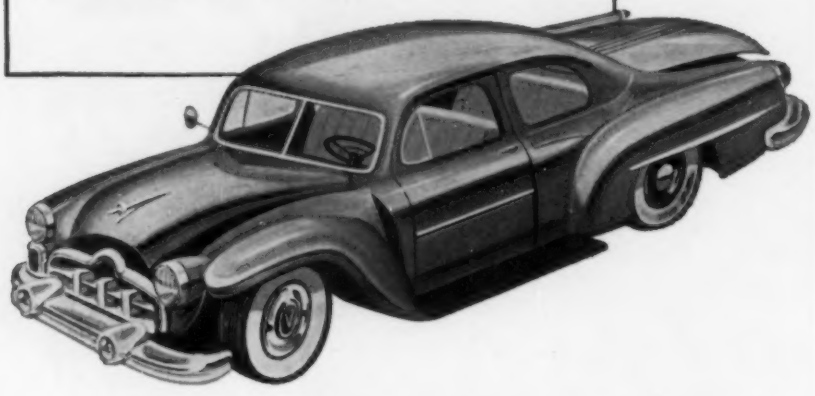
WESTFIELD, N. Y.

Does your servo system end up like this?



Of course, you've never bought an automobile in pieces, picking up a bumper here, a carburetor there, a clutch somewhere else. Even if you *could* arrive at the appearance and performance of a finished car, chances are it would require countless hours of work and a factory-full of fabricating equipment to integrate the odd sized parts.

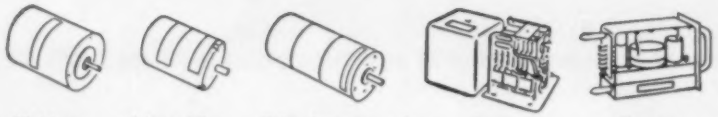
Surprising, then, how many companies build servo systems just this way. Buying parts from different manufacturers . . . putting them together and hoping for an ideal system. Either the final result is far below potential efficiency, or the time, labor, machinery, and materials wasted in trying to "fit" the components together boosts the cost astronomically.

Experience proves that complete assemblies of Transicoil components not only assure improved system performance but actually cost less than the total purchase price of the individual components acquired from several sources.

If you are now purchasing servo components from several manufacturers, a serious talk with Transicoil will pay you dividends in lower costs and a better system. But if you require only one component, you can be sure of optimum performance from the Transicoil units you specify.

TRANSICOIL

CORPORATION 107 GRAND STREET NEW YORK 13, N.Y.



Miniature Control Motors | Motor and Gear Train Assemblies | Motor, Generator, and Gear Train Combinations | Servo Amplifiers | Plug-In Assemblies

required, its linear resistance feature is asserted to prevent undesirable "hunting" or "chatter."

The new potentiometer provides resistances of from 500, 1000, 1500 and 2000 ohm, infinite resolution, and a normal and zero base linearity of 0.02 percent. Other specifications include: a shaft rotation of 60 turns +10, −0 deg; a power rating of 5 w at 25 C; and a resistance element life in excess of 1 million complete cycles of wiper through total travel and return. Link Aviation, Inc., Binghamton, N. Y.

For more information— Circle 68, inside back cover

Miniature Sine-Cosine Potentiometer

Functions are accurately and smoothly developed with this potentiometer, it is claimed. Four brush contacts move circularly over a uniformly wound rectangular card and pick off output angle at speeds up to 60 rpm. Standard resistance value is 16,000 ohm. Resistance from 4,000 to 25,000 ohm can be supplied. Accuracy at higher values is 1 percent. Power rating is 1 w at 40 C.

The envelope is $1\frac{1}{16}$ in. dia, $1\frac{7}{16}$ in. long, with standard servo mounting flange. Shaft is $\frac{1}{8}$ in. Case is black anodized aluminum. Meets or exceeds applicable section MIL-E-5272A for high and low temperature and vibration. Gamewell Co., Newton, Mass.

For more information— Circle 69, inside back cover

Oil Flow Control

This device provides a method of preventing excess oil flow in the event of air failure in pressurized burners, going into action when air flow is interrupted due to electrical failure, mechanical fan problems or clogging of the fan. Model 113A is completely mechanical and requires no electrical connections. It can, however, be supplied with a snap switch which will provide a means for shutting off the fan. Air pressure against a diaphragm actuates the unit, moving a lever arm to allow full oil flow.

Model 114B is actuated by a thermally responsive bimetal element

STAINLESS STEEL FOR TRANSPORTATION

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High quality stainless sheet and strip steel . . . for the product you make today and the product you plan for tomorrow.

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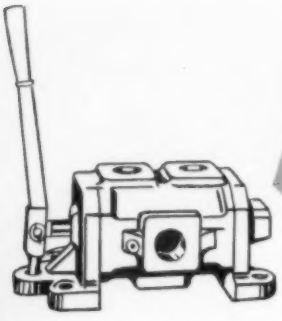
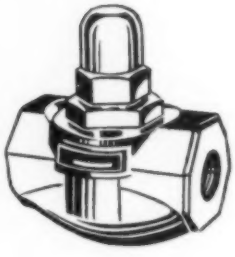
DETROIT, MICHIGAN
Manufacturers of Stainless and Carbon Steels

Logan HYDRAULIC VALVES.....



Illustrated, Model 4095 —4-way, 2-position valve for directing pressure alternately to ends of double-acting hydraulic cylinder.

Illustrated, Model 8015 adjustable speed control valve. Install between operating valve and one end of cylinder to meter flow of oil in one direction with free flow on return.



A broad range of types and sizes to most effectively meet any requirement—Design Engineers, Machine Operators, Maintenance Men appreciate these Logan advantages

- LONG-LIFE CONSTRUCTION
- EASY TO SERVICE
- INFREQUENT MAINTENANCE
- EASE OF INSTALLATION
- EFFORTLESS OPERATION
- UNRESTRICTED PORTING

On your products and in your plant, the enlarged line of standard Logan Hydraulic Control Valves offers many profitable advantages in selection, installation, use and maintenance. Standard Logan Hydraulic Valves are designed for 1500 psi service. The broad range of types and sizes makes it easy to select the most effective valve for every problem.

Balanced-pressure construction of these piston-type valves places identical pressure on both ends of the piston, thus providing effortless operation.

All ports and internal chambers are full pipe size with valve piston light in weight, thus assuring rapid response and fast reversal without excessive vibration or wear.

Highly compact design permits easy installation in restricted areas. Master control valves have four mounting feet located on end covers for easy mounting.

The valve body, which includes the ports, can be rotated 360° on the end covers to four positions at 90° intervals, when socket-head cap screws are removed from the covers. Permits convenient and efficient location of pipe connections. Alternate inlet ports, with one port plugged, provide added flexibility.

The ease with which pipe connections can be made often eliminates the necessity for costly special valves. Elimination of elbows, street ells, bends, etc. minimizes internal friction, thereby increasing efficiency and reducing costs.

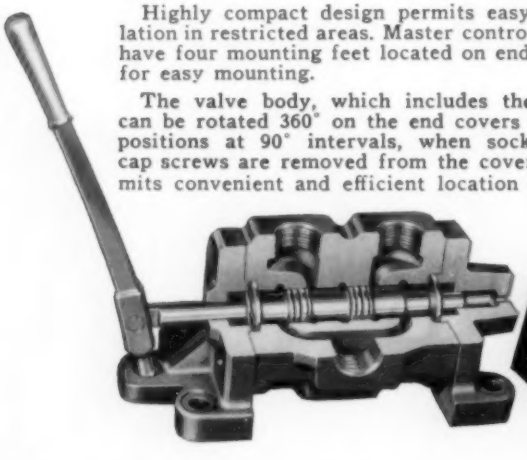
The tough, wear-resistant alloy steel piston, hardened and ground, provides a close, sliding fit in the valve body. Both body and end covers are chrome nickel iron castings which furnish a good bearing surface to assure superior wearing qualities.

Both wear and maintenance are reduced in the Logan sliding-piston construction through elimination of valve seats and packing. The two stem seals at ends of piston are subject only to exhaust pressures.

With the removal of end covers, the standard seals are easily replaced and the piston may be removed from the vaive body for examination without disconnecting the piping.

Logan Hydraulic Control Valves offer many other advantages which assure longer, more effective performance and low maintenance.

For full information write for Logan Catalog 200-4.



Let Logan Engineers help you design your Air and Hydraulic Circuits. You will not be obligated.

Wherever there's a holding or motion requirement, there's a Logan design to do the job.

Member—National Tool Builders Assn.; National Fluid Power Assn.

LOGAN MANUFACTURES 7,023 STANDARD CATALOGED ITEMS

FREE CATALOG ON REQUEST

AIR CONTROL VALVES, Cat. 100-4 • AIR CHUCKS, Cat. 70-1 • AIR CYLINDERS, Cat. 100-1 • AIR-DRAULIC CYLINDERS, Cat. 100-3
AIR and HYDRAULIC PRESSES, Cat. 51 • COLLET GRIP TUBE FITTINGS, Cat. 200-5 • HYDRAULIC CONTROL VALVES, Cat. 200-4
HYDRAULIC CYLINDERS, Cats. 200-2; 200-3 • HYDRAULIC POWER UNITS, Cat. 200-1 • SURE-FLOW COOLANT PUMPS, Cat. 62

SAVES TIME Logan AIR AND HYDRAULIC EQUIPMENT EFFORT-MOTION

LOGANSPORT MACHINE CO., INC., 812 CENTER AVE., LOGANSPORT, IND.

located in the air stream, and automatically reduces oil flow to a predetermined rate. The bimetal element keeps a constant safety check on air flow and trips out within seconds whenever trouble develops. This unit is available for use with either continuous or intermittent fan operation. A-P Controls Corp., Dept. B., 2450 N. 32 St., Milwaukee 45, Wis.

For more information—
Circle 70, inside back cover

Encapsulated Resistors For 0.50 to 1.50 W

These axial-lead resistors require no support other than that derived from their connected leads. They are said to be wound with tested resistance wire and sealed with mineral-filled epoxy resin. The contour of the outer coating insures a long leakage path between terminals, encouraging the breakage of moisture films which might lower resistance along ordinary plane surfaces. Shallcross Mfg. Co., Collingdale, Pa.

For more information—
Circle 71, inside back cover

Impulse Steam Trap For Light Condensate Loads

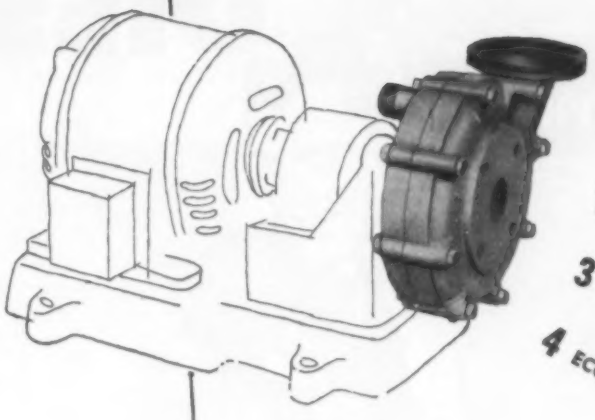
This ½ in. impulse steam trap was designed with low capacity to handle light condensate loads. It is stated that it will not freeze or air-bind on steam tracer line service. It also can be used on such light load applications as small platens, autoclaves, hospital sterilizers, unit heaters, clothing presses. Body and all working parts are made of stainless steel, good for all pressures to 400 psi. Yarnall-Waring Co., 100 Mermaid Ave., Philadelphia 18, Pa.

For more information—
Circle 72, inside back cover

Capacitor With High Leakage Resistance

These capacitors have as their dielectric a polystyrene plastic film that is said to make them the first polystyrene capacitors suitable for operation up to 85 C. Dielectric absorption,

only 1 material has all 4



1 CORROSION RESISTANCE
2 STRENGTH
3 DIMENSIONAL STABILITY
4 ECONOMY

...for ACID PUMPS for instance

One of the strongest plastics known . . . .Ace Hard Rubber . . . got the nod for the impeller and casings of this acid pump. Why? (1) It's resistant to almost all corrosives; (2) High strength and abrasion resistance; (3) Won't warp or swell; and (4) Costs much less than corrosion-resistant alloys. Typical result: On one job this hard rubber pump handles 12% hydrofluoric acid, turns on and off twice a minute, 24 hours a day, six days a week . . . a mighty tough test for corrosion-resistant materials?

Many other Ace hard rubber compounds are available . . . tensiles as high as 10,000 psi, moisture absorption as low as 0.04%, power factor as low as 0.006, heat resistance to 300 Deg. F. . . . also many new plastics and rubber-resin blends. All Ace compounds are tailor-made to fit the job . . . never *over*-designed. That's why Ace is the *only* material that meets all four big requirements for parts like acid pumps.

and here's a 5th

Hard rubber sleeve provides electrical insulation as well as mechanical and chemical strength in this coupling for electroplating agitator.

80-pg. Ace handbook free to design engineers.

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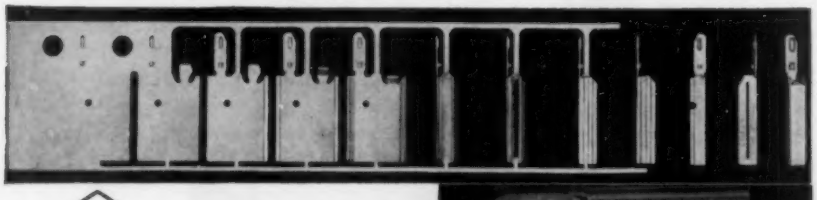
Why PRODUCTION B. Jahn PROVED DIES

eliminate assembly problems for Engineers

The anxiety of the engineer is eliminated when B. Jahn builds dies! B. Jahn can construct a die for a single component or a number of progressive dies for complete assemblies — and submit 10 to 50,000 units for inspection and actual assembly line use. All tooling and production problems are therefore solved before the die is certified "production proved" and shipped — and the progressive engineer is guaranteed a die that will run in his equipment to his complete satisfaction.



Die ribbon for Eversharp-Schick Injector Razor Blade Holders being "production proved" — performance: 58 units per minute; precision: to micro-tolerances.

Some of 50,000 complete units submitted for manufacturer's gaging & approval before die was shipped.

Yours on request — the graphic "Story of B. Jahn Production Proved Dies."

B. Jahn

THE B. JAHN MANUFACTURING COMPANY • NEW BRITAIN, CONNECTICUT

or recovery of charge after discharge, is negligible. Leakage resistance is in the excess of 1 million megohm-microfarads. Time constant, as measured by loss of charge in standing, is on the order of 10,000 hr.

Available in various mechanical configurations to meet individual needs, all these new capacitors are hermetically sealed. Operating temperature range is −55 C to 85 C. Sprague Electric Co., 195 Marshall St., N. Adams, Mass.

For more information— Circle 73, inside back cover

Thermodynamic Steam Trap

The kinetic energy of steam is said to close this trap's valve. The only moving part is the valve head, a heat-treated stainless steel disc. The same head and seat are used for pressures to 600 psi, temperatures to 950 F.

The new steam trap closes tight on no load, and operates against a back pressure up to 50 percent of its inlet pressure. It discharges condensate at saturated steam temperature as rapidly as it forms. This trap can vent large volumes of both air and air-steam mixtures. The starting load capacity is high, but it operates equally well with light loads or no load.

The 1-in. trap size is 3½ x 4¾ x 4 in. high. Bodies of cast semi-steel, carbon or molybdenum steel are available, with screwed, socket weld or flanged connections. Sarco Co., Inc., Dept. P, Empire State Bldg., New York 1, N. Y.

For more information— Circle 74, inside back cover

Crankcase Pressure Regulating Valves

This valve protects compressor motors against overload and possible burnout caused by high torque loads due to excessive suction pressure. At high suction pressure load, the Model 237 valve will regulate flow to the compressor inlet. Only a safe back pressure is allowed to develop and by modulating action, the valve will vary the flow to maintain the pressure limit setting. The pressure range is adjustable and can be fixed at a point between zero to 40 lb.

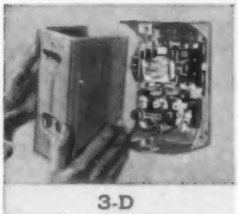
Two models are available—with ca-

Now Cutler-Hammer ★★★ Motor Control in NEMA Size 2 for motors up to 25 HP*

★ *installs easier*
★ *works better*
★ *lasts longer*

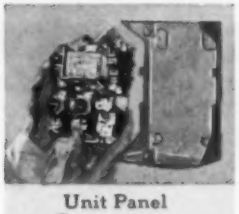
It is here . . . Cutler-Hammer ★★★ Motor Control for your larger motors, NEMA Size 2 Starters with the famous three stars on the Cutler-Hammer nameplate. The three stars that stand for three entirely new standards in motor control performance and value. Star #1: Installs easier. So much easier that installation savings often exceed the cost of the control. Star #2: Works better. So much better that this control often pays for itself many times over in just the production interruptions it avoids. Star #3: Lasts longer. So much longer that this control *never* needs maintenance care or expense in 90% of its uses. If you are one of the many users who have proved these are facts, not mere claims, you will welcome the news that your larger motors can now have this same control. Order Bulletin 9586, Size 2, today from your nearby Cutler-Hammer Authorized Distributor. He is stocked and ready to serve you. CUTLER-HAMMER, Inc., 1332 St. Paul Ave., Milwaukee 1, Wisconsin.

CUTLER-HAMMER
★ ★ ★
MOTOR CONTROL
C-H



3-D Accessibility

Removing the wrap-around cover bares the entire starter for three-directional accessibility. It is wide open at front and both sides. You can see everything and reach anything. Wiring the starter is simplified and routine inspection is made so easy and complete nothing is ever neglected.



Unit Panel Construction

The entire starter mechanism can be removed from its case by simply loosening three screws. With mechanism out of the way, mounting case, connecting conduit and pulling wires is a cinch. A great time saver. No skinned knuckles. No damaged starter mechanisms.

Full Three-Phase Protection

Only three overload relays can provide positive three-phase protection to stop needless motor burn-outs and production interruptions. And only Cutler-Hammer offers three overload relays in *standard* starters without the excessive costs and delays of special starter constructions.

Adjustable Sensing Coils

Only the accurate adjustment of overload protection permits motors to work harder without damage. Now more important than ever with newer type small frame motors. Only C-H offers adjustable load sensing coils . . . for 3% loading accuracy instead of the 10% to 12% in all other controls.

Superlife Vertical Contacts

Now the famous C-H dust-safe vertical contacts have been doubly improved. New light-weight design cuts bounce to reduce arcing. Also, arcing is now pressure-quenched. Contact maintenance care and costs are ended for all time in all normal motor control uses.

For Control Panel Designers

The new Cutler-Hammer ★★★ Motor Control offers an array of spectacular new features to provide many exclusive advantages in circuit planning, compact panel design, better motor protection and better control performance. Be sure you have complete design data on this advanced equipment. Write or wire today.

New Control Components

All parts of the new C-H ★★★ Starters in NEMA 0, 1 and 2 Sizes are available as components, also complete starters on convenient unit panels. Electrical interlocks are available to provide additional control circuits when desired.

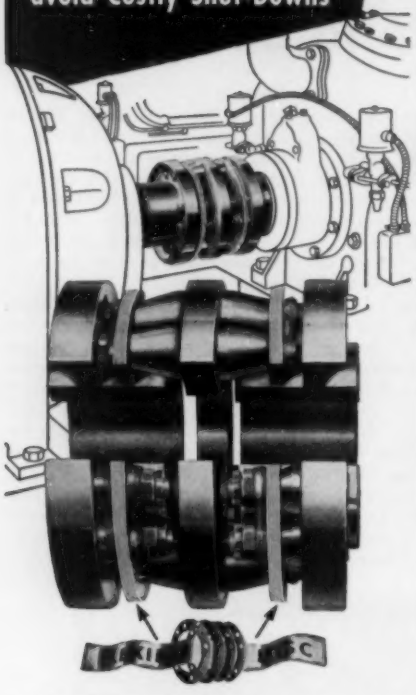
New Control Relays

Finest of control relays. 10 and 15 Amp. 2-3-4-5-6 poles. All contacts instantly convertible from NO to NC or vice versa. NO or NC status seen at a glance without removing cover. New armored magnet coils color coded for voltage and frequency.

New SD & HD Pushbuttons

New standard duty pushbutton station with pilot light offers many exclusive features, typical of complete C-H line. Watch soon for announcement of the revolutionary new line of C-H heavy-duty all-tight one-hole mounting pushbuttons.

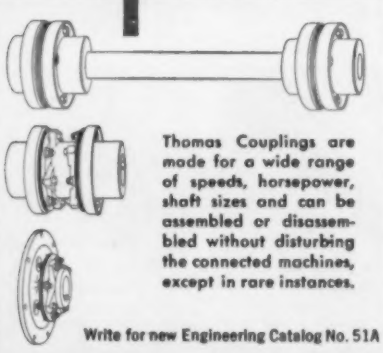
Specify THOMAS ALL METAL
FLEXIBLE COUPLINGS
for Power Transmission to avoid Costly Shut-Downs



Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.

DISTINCTIVE ADVANTAGES

FACTS	EXPLANATION
NO MAINTENANCE	Requires No Attention. Visual Inspection While Operating.
NO LUBRICATION	No Wearing Parts. Freedom from Shut-downs.
NO BACKLASH	No Loose Parts. All Parts Solidly Bolted.
CAN NOT "CREATE" THRUST	Free End Float under Load and Misalignment. No Rubbing Action to cause Axial Movement.
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.



Thomas Couplings are made for a wide range of speeds, horsepower, shaft sizes and can be assembled or disassembled without disturbing the connected machines, except in rare instances.

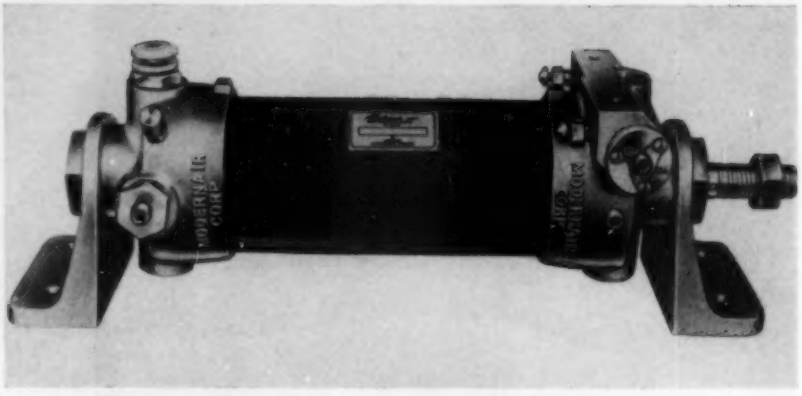
Write for new Engineering Catalog No. 51A

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

pacities of 1½ and 3 ton, Freon 12. These are nominal capacities at 2 lb pressure drop. Standard connection sizes in the 1½ ton valve are: ⅝ in. SAE male flare, ⅞ in. in the 3-ton model, ⅞, and 1⅛ in. OD solder. Valve connection eyes in the 3-ton model are 1⅛ and 1⅜ in. OD solder. A-P Controls Corp., 2450 N. 32 St., Milwaukee 45, Wis.

For more information—
Circle 75, inside back cover

HYDRAULICS AND PNEUMATICS



Co-Axial Air-Hydraulic Cylinder

The air cylinder in this unit surrounds the oil cylinder, providing shorter overall length. Expanding exhaust air is said to also help cool the oil. Automatic models are available with built-in controls (remotely operable if desired) of speed, direction, adjustable fast traverse in either direction, and automatic recycling. Standard models can be remotely controlled with conventional valving and piping.

The cylinder develops hydraulic piston thrust of 3.14 times available airline pressure, and a pull of 2.7 times available airline pressure. Stroke length up to 72 in. may be obtained. Modernair Corp., 400 Preda St., San Leandro, Calif.

For more information—
Circle 76, inside back cover

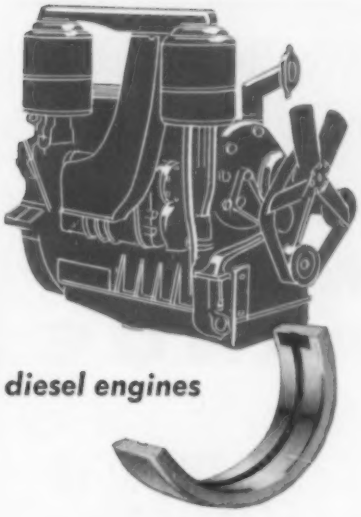
Hydraulic Steering Booster

Designed for trucks, buses, material handling equipment, construction and mining machinery this booster has a new servo control valve design and relocated hydraulic connections. The device is available either with or without relief valve, and can be either factory-installed or mounted on vehicles in service. Installation of the new booster is made easier because of reduced diameter, in addition to mounting adaptability provided by a symmetrical control ball stud housing that can be assembled in any one of four different positions. The steering booster transmits all road shock to the the chassis, so that the steering wheel cannot be jerked out of the driver's control when ruts or obstructions are encountered.

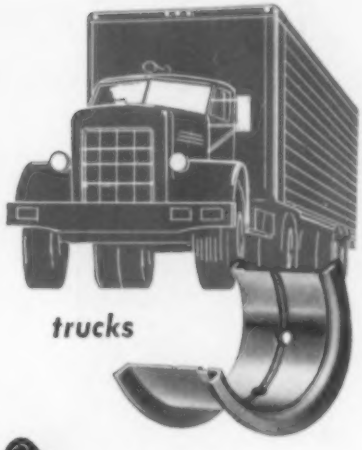
The Series S23 design is available in two models: the S23-070 and S23-120. The "070" has a 7-in. max stroke and the "120," a 12-in. max. Each has a 3,000 lb rated thrust capacity at 600 psi. Maximum operating pressure is 1000 psi.

Basic dimensions of the S23-070 are as follows: retracted working length, 20$\frac{13}{32}$ in.; extended working length, 27$\frac{13}{32}$ in.; overall extended length, 33$\frac{5}{32}$ in. Basic dimensions of the S23-120 model are: retracted working length, 25$\frac{13}{32}$ in.; extended working length, 37$\frac{13}{32}$ in.; overall extended length, 43$\frac{5}{32}$ in. The major height

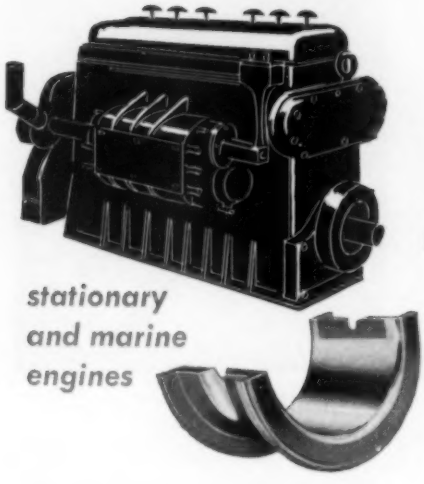
agricultural equipment



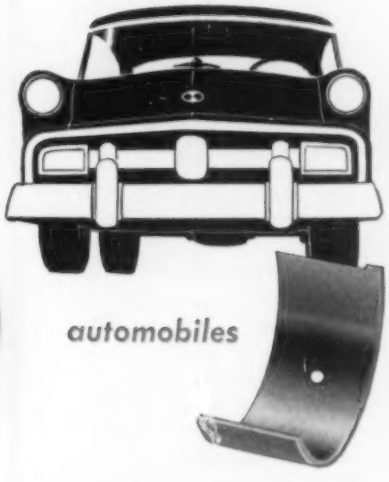
diesel engines



trucks



stationary and marine engines



automobiles

military equipment

earth-moving equipment

diesel locomotives

. . . . . leaders in every field use Federal-Mogul bearings — product of research, metallurgy and precision manufacture. Your inquiry is invited.

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since 1899

BEARINGS . . . *for Smooth Flowing Power*

FEDERAL-MOGUL CORP. 11043 Shoemaker, Detroit 13, Michigan

'Diamond H' Miniature, Hermetically Sealed, Aircraft Type Relays

Shown Actual Size

HAVE A WIDER RANGE OF PERFORMANCE CHARACTERISTICS

IF YOU need a relay that will operate consistently under extremely critical or downright adverse conditions, there's an excellent possibility your requirements can be readily met by one of the multitude of variations possible with the basic "Diamond H" Series R relay. Originally designed to meet all requirements of USAF Spec. MIL-R-5757B, they far surpass many. They're adaptable to a wide variety of applications . . . guided missiles, jet aircraft, fire control and detection, radar, communications, high speed camera, geophysical and computer apparatus, for example.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 10 "G"
Temperature Range:	—55° to + 85°C. —65° to + 125°C. —65° to + 200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,250 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3ms.
Contacts:	30V., D.C.; 115V., A.C.; 2, 5, 7½ and 10A., resistive; 2 and 5A. inductive. Minimum 100,000 cycles life. Low interelectrode capacitance — less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs — plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Call on "Diamond H" engineers to work with you in developing a variation to meet your specific requirements.

THE HART MANUFACTURING COMPANY
206 Bartholomew Avenue, Hartford, Connecticut

(5$\frac{3}{32}$ in.) and the major width (3$\frac{1}{2}$ in.) dimensions are identical for both models. These values are exclusive of the control ball stud length. Straight thread connections are provided at pressure inlet and discharge outlet for use with SAE hydraulic fittings and "O" ring seals for $\frac{1}{2}$-in. OD tubing. Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.

For more information—
Circle 77, inside back cover

Solenoid-Piloted Air Valve

This air valve is solenoid-piloted by full line pressure (not bleeder piloted) and as such is reported to be capable of higher actuation rates, operating on shorter electrical signal, with shorter reaction time, than most valves of its type. The new unit is available in two models, single solenoid, spring return and double solenoid. Both models are available in $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in. (modified) NPT sizes, three or four-way, for operation on d-c current of 1.4 to 475 v, and a-c current of 3.6 to 750 v, in cycles of 25, 30, 40, 50, and 60. The valves are equipped with a $\frac{1}{2}$ in. NPT electrical conduit outlet. Beckett-Harcum Company, Inc., Wayne Road, Wilmington, Ohio.

For more information—
Circle 78, inside back cover

Solenoid Gas Valves

The power element in this valve is mounted on a synthetic rubber base enclosed in a sound-deadening chamber. Its seat is also of synthetic rub-

ber and this is a compression spring closure. A spongy piece of the same material as the seating is used in the assembly that attaches the aluminum closing disk to the plunger, cushioning the impact of the valve opening and closing.

This construction is reported to eliminate practically all transmission and radiation of sound to pipe, mounting structure or outer valve casing, as there is no direct contact between any metal parts that might transmit operating sounds.

These valves operate from a current of 0.4 amp. They may be used with all types of gases, including LP and those with high sulphur content. Optional is the easy-to-use knob type manual operator, conveniently located on the side of valve, for use in event of power failure.

Available in ½, ¾ and 1 in. sizes with capacities of 340, 450, and 775 cfh, these valves are for use with currents of 25v and 115v 60 cycle, ac. Pressure rating is ½ psi. White-Rodgers Electric Co., 1209 Cass Ave., St. Louis 6, Mo.

For more information—
Circle 79, inside back cover

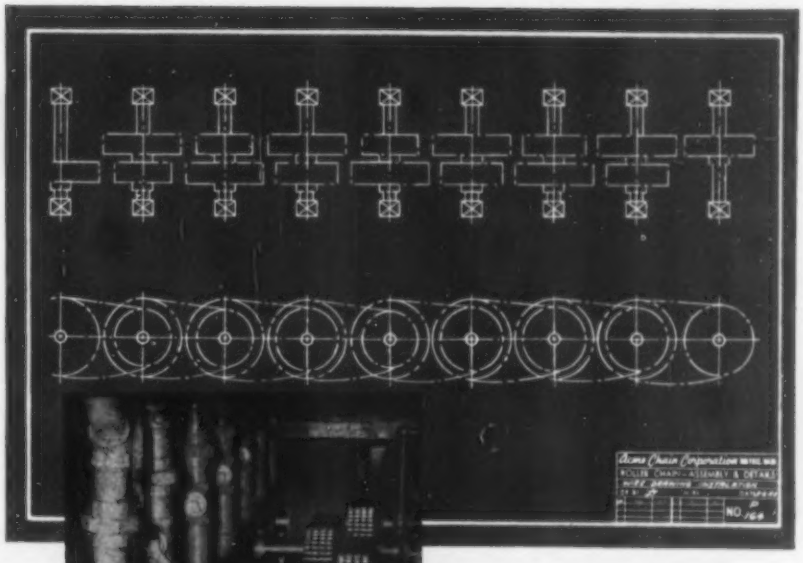
Hydraulic Cylinder Mounting

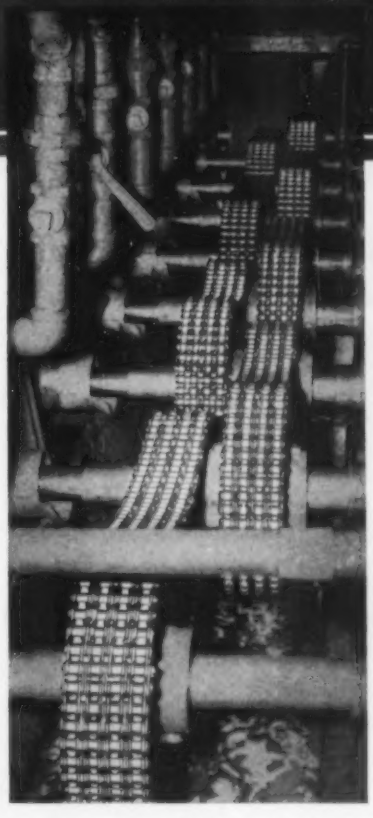
A hydraulic cylinder mounting consisting of square mounting lugs that mount flush with this manufacturer's standard square heads and caps permits side or foot mounting. The Model 77 is said to fit in less space because of lower centerline height. It is available in 1½ to 20 in. bores in 200 psi air cylinders; 1½ to 12 in. bores in 2000 psi hydraulic cylinders. It is also available in all the bore-and-stroke sizes made by this manufacturer for immediate, off-the-shelf delivery. Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.

For more information—
Circle 80, inside back cover

Cylinders For Hydraulic Or Pneumatic Systems

These cylinders can be operated by either air or oil with operating pressures up to 1,000 psi, according to the manufacturer. They comply with





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Norgren

MICRO-FOG LUBRICATION

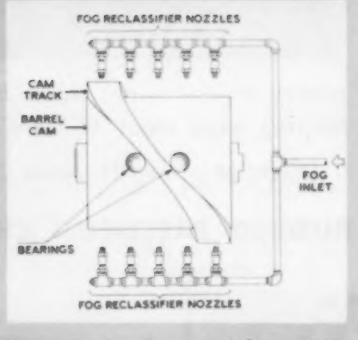
can help you

- **reduce machine wear**
- **increase bearing life**

Here's what Micro-Fog did for UNIVERSAL MATCH CORP. on 6 large printing presses

- **eliminated flaking and galling of cam track**
- **eliminated heating and excessive wearing of bearings**
- **eliminated constant squealing of barrel cam**
- **eliminated daily manual lubrication**

Oscillating movement of table on the printing press is achieved by a 16" dia. barrel cam rotating at 150 rpm. A Norgren Lubro-Control Unit (Filter, Regulator, Lubricator) was installed to lubricate the cam, cam track and follower roll bearings. It solved the lubrication problem so successfully that similar units were installed on the other five presses.



Two ¼" pipe lines, 18" long, carry Micro-Fog to 5 reclassifiers on each side of barrel cam. 10 psi air pressure used. Solenoid valve coordinates lubricant flow with press operation.

FOR COMPLETE DETAILS WRITE FOR NORGREN BLUEPRINT No. 118

C. A. Norgren CO.
3428 So. Elati, Englewood, Colo.

VALVES • FILTERS • REGULATORS • LUBRICATORS • HOSE ASSEMBLIES

both the JIC pneumatic standards and the JIC hydraulic standards.

"U" cup seals used on the piston and the rod have flexible lips to assure positive sealing at low air pressures and heavy web sections for strength required for sealing pressures.

The piston rod seal and rod wiper are mounted in a single cartridge which is easily removed to replace seals or wiper when required. Newly designed cushions prevent internal damage and excessive noise at high speeds. The Series "S" cylinders are offered in bore sizes from 1½ to 8 in. and in seven different mounting styles. Any stroke length is available, many from stock for immediate shipment. These cylinders can be furnished with hardened rods, special mountings, and many modifications for unusual conditions. Cylinders especially constructed for water service are also available. Hydro-Line Mfg. Co., 5742 Pike Road, Rockford, Ill.

For more information— Circle 81, inside back cover

Automatic Bleeding Valve For Hydraulic Systems

This self-bleeding valve is asserted to constantly and automatically bleed air out of a hydraulic system while the system is in operation. They are connected adjacent to the entrance ports of the hydraulic cylinders.

Two valves are therefore required for every double-acting cylinder, and one valve for a single-acting cylinder. On hydraulic brakes, however, only one valve is required for the entire system. Hydraulic tubing, suitably connected to these valves, complete the installation. These valves are made for all standard size lines, and for all pressure ranges. Radial Metal Products, Inc., 1044 Linwood St., Brooklyn 8, N. Y.

For more information— Circle 82, inside back cover

Moisture and Oil Separator

A moisture, dirt and oil separator for compressed air lines and equipment is rated at 125 cfm at 100 lb pressure. Equipped with four cellular filters, Model 125S is designed to handle 2 million or more cubic feet of com-

HOW Norgren Spray-Lube System CAN SIMPLIFY DESIGN OF MACHINE TOOLS

and provide many profitable advantages for users

FOR EXAMPLE

A-P CONTROLS CORP.

Machine taps 12 holes of various sizes simultaneously. Norgren Spray-Lube System includes 4½ gal. tank, 12 mixing valves and spray nozzles. Air and fluid line pressures are 42 psi and 44 psi respectively.

installed Spray-Lube on tapping machine...

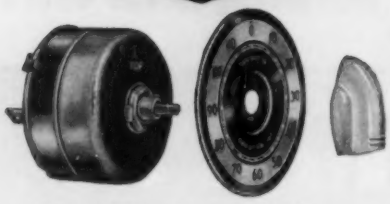
- increased tap life
- increased tapping speed
- eliminated problem of chips plugging coolant lines
- eliminated messy condition of splashing coolant

FOR COMPLETE DETAILS WRITE FOR NORGREN BLUEPRINT No. SL-4

VALVES – FILTERS – REGULATORS
LUBRICATORS – HOSE ASSEMBLIES

C. A. Norgren CO.
3428 So. Elati, Englewood, Colo.

MARK-TIME
"9200"
Bell Signal
Time Switch



Specifications: U/L approved. 30 amp. ½ hp., 120-240 v. AC only. Diameter, 2 19/32"; depth, 2 5/64"; center stud mounting.

Combines
LOW COST
VERSATILITY
SALES APPEAL

The Mark-Time 9200 Bell Signal time switch has been redesigned to **increase** its already wide acceptance. This switch has proven itself on clothes dryers, ranges, broiler-rotisseries, battery chargers, washing machines, and in many other applications where an automatic time switch and bell signal are needed. It is the most versatile bell signal time switch on the market . . . available in various combinations of circuit arrangements and dial styling, and ideal for all heating elements with high voltage requirements.

The "9200" is a streamlined, durable, low cost unit which normally breaks two circuits simultaneously (DPST), and at the same time sounds a clear, resonant bell signal. It is designed for easy, economical installation on all ranges and other appliances, and is engineered for rugged dependability, accuracy and high quality.

Write today for full details and prices.

MARK-TIME **FIRST where quality counts**

M. H. RHODES, INC.
HARTFORD, CONNECTICUT

Manufactured and sold in Canada by
SPERRY GYROSCOPE OTTAWA, LTD.,
Ottawa, Ontario, Canada

pressed air without change of filter elements. Beach Precision Parts Co., 120 Mechanic St., Boonton, N. J.

For more information—
Circle 83, inside back cover

Solenoid Valve for Up to 3,000 psi

A series of solenoid valves, designed for operating pressures to 3,000 psi and ambient temperatures to 500 F and said to be particularly applicable to guided missiles, rockets and aircraft, are either direct-operated or pilot-operated by means of a single coil solenoid of the 18 to 30 v, dc, type. Higher voltage solenoids are available. The continuous duty solenoid actuates the valve in the normally closed or normally open two-way or three-way position, controlling fluid or gas flow as required.

A wide range of gases and liquids can be handled, including corrosive types. These valves have been proved for handling air, nitrogen, helium, oxygen, hydraulic oil, red or white fuming nitric acid, aniline, hydrazine, ethylene oxide, propyl nitrate, liquid oxygen and hydrogen peroxide. Futurecraft Corp., Dept. H-1, 1717 N. Chico Ave., El Monte, Calif.

For more information—
Circle 84, inside back cover

Fittings for Hydraulic Hose

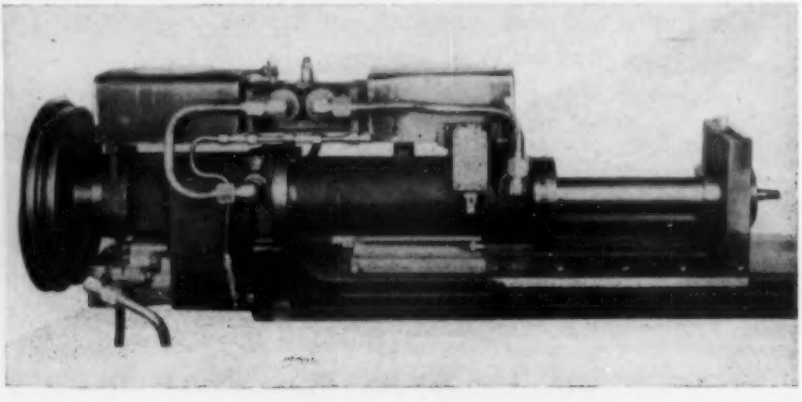
This connector has a swivel nut on one end and male pipe thread on the other. It permits installation in those instances where otherwise direct

Hydraulic Unit for Production Equipment

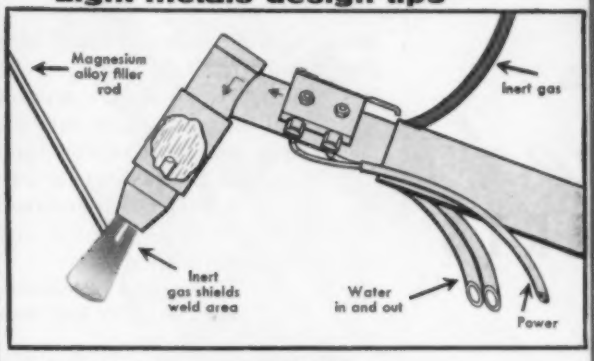
The ram of the 1½ hp Model E is coaxial with its spindle, exerting full force directly behind the head. The splined spindle shaft extends through the center of the cylinder, piston and ram, and projects through the face of the ram head. This is said to eliminate lateral components of force on the head, which would tend to force the head out of line under heavy pressure and impose undue stress on the unit. Spindle driving sheaves are mounted on a housing to which the cylinder head is attached. Use of a support at the spindle end of the ram eliminates "wobble" according to the manufacturer. This support rides on ways, with which the unit is furnished, throughout the length of its stroke. Laborious designing of guide bars and other auxiliary equipment is not required in adapting the unit.

The new device is obtainable with a ram stroke of 6, 9, or 12 in. Feed rate is 0 to 8 in. per min, with a traverse speed of 240 in. per min. Since pump and spindle are driven independently, pump speed can be set for any traverse speed required to synchronize with other units. Spindle speed can be set for 600 to 3600 rpm. A two-solenoid valve is employed to operate the ram in both directions. When synchronized with other units, this valve is interlocked in such a way as to return the ram in case of emergency. Rock River Engineering Co., Empire Bldg., Rockford, Ill.

For more information—
Circle 85, inside back cover



Light metals design tips



Shielded arc welding of magnesium broadens design possibilities

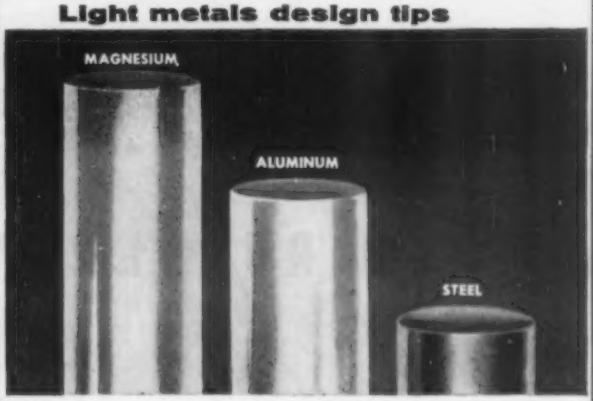
Successful welding of magnesium by the inert gas shielded arc method—best illustrated by the drawing above—has made it possible for the designer to utilize high-strength, low-weight magnesium in ways not previously possible.

Specifically, welding by the inert gas shielded arc method calls for the use of a special torch designed to hold a tungsten electrode; this torch introduces an inert gas around the electrode, thereby shielding the weld area. The arc is struck between the tungsten electrode and the work. A filler rod of the proper alloy adds metal as needed or required. The source of current may be either A.C. or D.C.

Whatever your light metals problem . . . count on Magcoa engineering counsel and fabrication facilities.

MAGNESIUM COMPANY OF AMERICA
LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

Light metals design tips



How to figure weight savings in magnesium structural assemblies

Because of its unusually high strength-weight ratio, magnesium is getting more and more consideration in the design of structural units. To achieve maximum weight savings over other materials, increase the depth of the sections . . . thus maintaining equivalent strength by increasing the moment of inertia or radius of gyration.

Generally speaking, when you replace steel with magnesium a weight saving of 65% is possible under static load conditions. Under a dynamic load or rough handling, a 50% weight saving is achieved. An 18% saving is to be expected when magnesium replaces aluminum under either static or dynamic load conditions.

We welcome the opportunity to discuss weight saving possibilities with you. Magcoa engineering assistance and fabrication facilities are at your disposal.

MAGNESIUM COMPANY OF AMERICA
LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

Introducing a new service for readers of Product Engineering

Shown above are two in a series of advertisements to run in the pages of this publication, starting next month. Though small in size, each ad will give you, the readers of PRODUCT ENGINEERING, helpful hints on practical, economical use of light metals in product design.

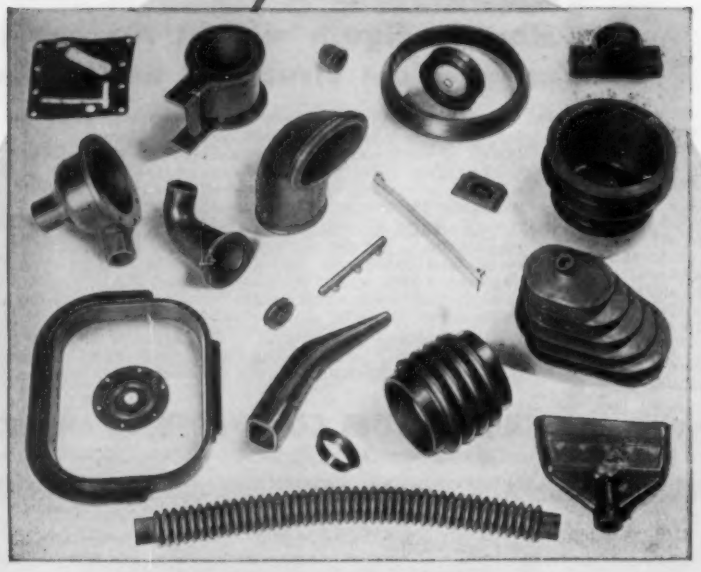
We know that if you clip and save each ad of this series you will have a compact, "pocketbook" edition of what's new in the light metals design field.

Take a look at the two ads again. Read the copy. They are representative of what will follow—brief, helpful, informative ads, talking about just one thing: light metals.

A suggestion: from now on, look for the little Magcoa ads toward the back of the issue (or check the advertisers' directory) to find the current light metals design tip written for *you* by

MAGNESIUM COMPANY OF AMERICA
LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

Custom Engineered
MOLDED RUBBER PARTS



ACUSHNET specializes in "precision" molded rubber parts custom-engineered to specific requirements.

Utilizing the most modern techniques, our Engineering Staff constantly is developing new approaches to old problems, with notably successful results. By ingenious mold designing and skillful compounding, yesterday's skepticism of rubber for certain uses has changed to complete confidence in this versatile material as ideal for applications in countless vital assemblies.

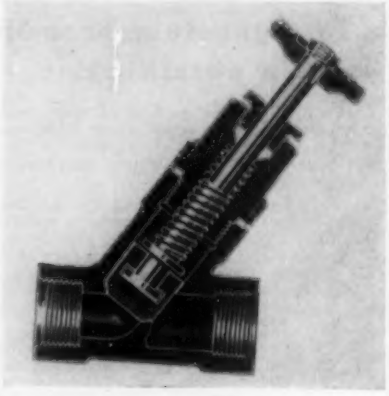
Acushnet
PROCESS COMPANY

Consult our engineers on your next precision molded rubber job. In the meantime, send for a copy of the "Acushnet Rubber Handbook", a comprehensive rubber data reference for molded rubber parts.

Address all communications to 768 Belleville Ave., New Bedford, Mass.

mounting of the male pipe thread hose fitting would result in twisting of the hose. The swivel nut of the connector has straight threads to screw onto the male fitting, which is specially chamfered to provide a metal-to-metal seating, assuring a leakproof connection. Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

For more information—
Circle 86, inside back cover



Valves and Fittings of Molded Pvc

Said to be the first completely molded PVC valve, this component is molded in rigid form of polyvinyl chloride, suitable for pressures up to 125 lb and 150 F temperature. It is presently available in a "Y"-type globe design.

A line of fittings made of the same material includes caps, couplings, plugs, unions, reducing bushings, flanges, 45-deg and 90-deg elbows and tees. Lunkenheimer Co., Cincinnati 14, Ohio.

For more information—
Circle 87, inside back cover

Toggle-Actuated Valve

This valve is available with either bronze, aluminum, steel or stainless steel body and a neoprene diaphragm. Bonnets can be furnished with or without threading on the outside diameter for panel mounting. In addition, a toggle-actuated three-way valve is available with a vent to the atmosphere.

When the toggle is in neutral position on the three-way TV-3, the flow is through the valve and the at-

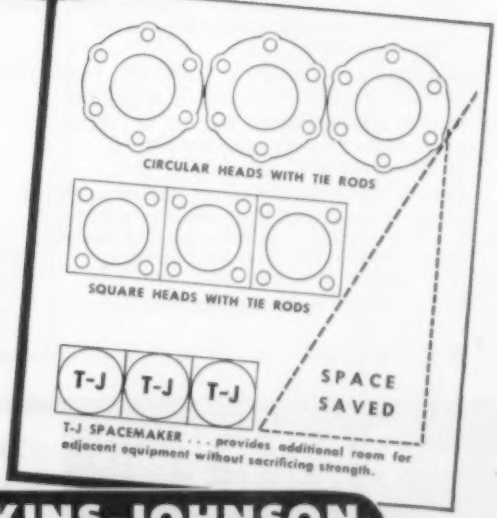
Rx for . . . AUTOMATION

OFF SHELF DELIVERY!

T-J Spacemaker CYLINDERS

- ★ OIL pressure to 750—AIR to 200 P.S.I.
- ★ New Compact Design . . . Saves up to 40% Space
- ★ Proven Performance . . . with Extra High Safety Factor
- ★ Super Cushion Flexible Seals for Air . . . New Self-Aligning Adjustable Oil Cushion
- ★ Hard Chrome Plated Bodies and Piston Rods

Compare feature by feature—you'll see why T-J Spacemaker Cylinders are today's top choice for streamlined power movement in automation! The only cylinder with all the extras as standard. Write for bulletin SM-454-2. The Tomkins-Johnson Co., Jackson, Mich.


CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
T-J
T-J
T-J
SPACE SAVED
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

T-J TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

Shock and Vibration ISOLATORS

BARRY B MOUNT

effective in all directions

Photo courtesy Raytheon Mfg. Co.

Type 1000-2000-4000-3000 Barrymounts isolate short-duration shock and high-frequency vibration above 45 cps.

Four sizes: Load ranges of 7 to 50 lbs., 15 to 125 lbs., 100 to 450 lbs., and 70 to 350 lbs.

Positive self-captivation security is a feature obtained by the design and assembly of the metal parts.

Smooth load-deflection curves through rubber-in-compression construction, assure protection of sensitive equipment in vehicular and shipboard installations. Vertical natural frequency at rated loads is 25 to 30 cps.

Equal stiffness in all directions permits use in any attitude.

Write today for information on these Barrymounts.

Do you know about these Barry services?

- Basic research on shock, vibration, and noise control
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- Application engineering
- Development engineering
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Call your nearest Barry Representative

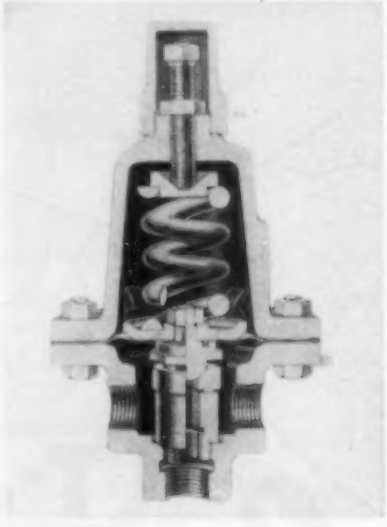
THE BARRY CORP. 730 PLEASANT STREET WATERTOWN 72, MASS.

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

mospheric vent is shut off. When the toggle is tipped, so that it is no longer in its neutral position, the inlet to the valve is shut off and the downstream side is vented to the atmosphere.

The toggle has a universal tilting angle and is made out of case hardened steel, chrome-plated. The bonnets may be furnished anodized in various colors for coding purposes. They are currently being used on pressures up to 200 psi air and have been tested on air pressure up to 500 psi. The outside diameter is 1½ in. and the overall height is approximately 2 in. George W. Dahl Co., Inc., 430 High St., Bristol, R. I.

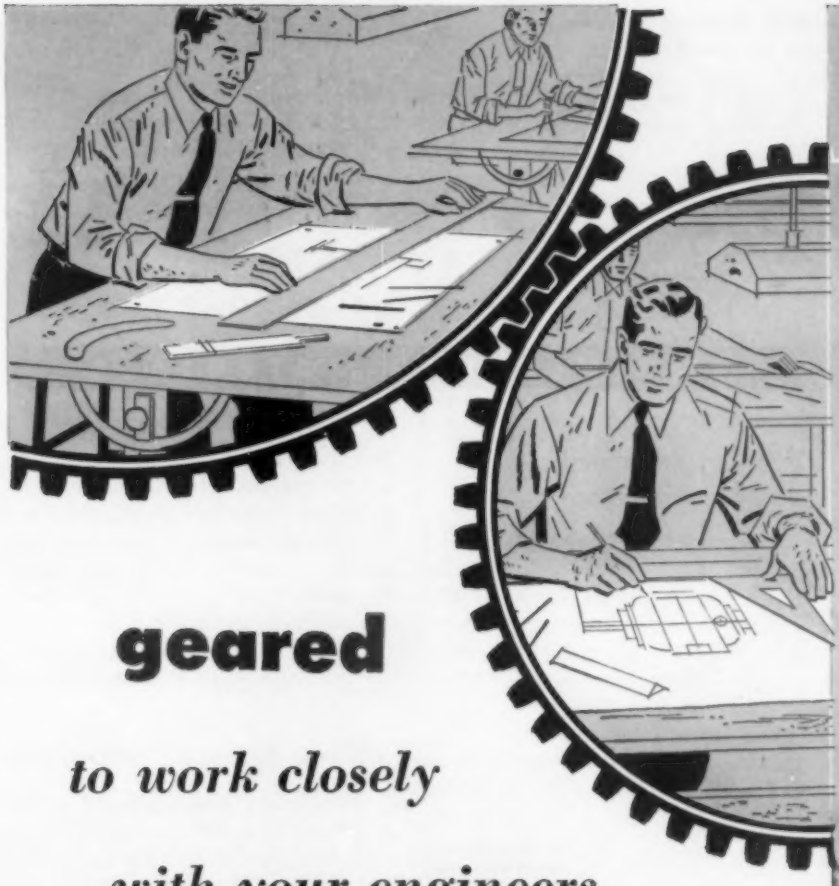
For more information— Circle 88, inside back cover



Back Pressure Relief Valves

Available in pipe sizes ½ to 2 in., in iron, bronze, stainless steel or Monel bodies, these valves are suitable for pressures up to 400 psi, according to the manufacturer. These valves were designed to maintain a predetermined pressure on their inlet side and are substantially unaffected by pressure variations on their discharge side. After a slight modification, these new components can be used as differential pressure regulators, to hold a constant difference in pressures between inlet and outlet parts.

The spring above this valve's diaphragm exerts its force downward to hold the valve closed. Fluid pressure entering the inlet below the dia-



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to work closely

with your engineers

on motor-driven products

We work so closely with customers that some consider our facilities a part of their own operations.

Close cooperation of our staff with your purchasing and engineering departments assures the right motor for your product.

This can mean improved product appearance, reduced weight, greater compactness and lower costs.

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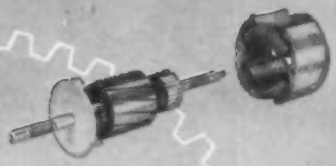
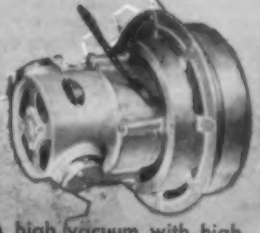
In Canada: Lamb Electric —
Division of Sangamo Company Ltd. — Leaside, Ontario

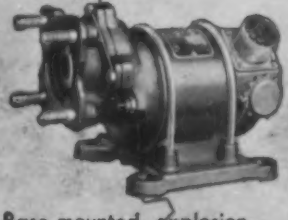


Motor parts for floor polishers, food mixers and other household appliances.

Motor with worm gear reduction for vending machines and similar applications.



A high vacuum with high volume turbine unit for vacuum or blower applications.



Base-mounted, explosion-proof aircraft geared fuel transfer pump motor.

If you are interested in any of the above motors write and we shall be glad to send full information.

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

NEW

Assembly Plant helps meet increased demand for O-M cylinders!...*

*Standard, semi-standard and "special" air and hydraulic cylinders all assembled from large, complete shelf stocks of component parts, then tested and shipped directly from Ortman-Miller's modern new assembly plant . . . assures the *right* cylinder for the job, *delivered in LESS TIME!*

O-M CYLINDERS

fit where others won't

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Address _____
City _____ Zone _____ State _____

phragm is the opposing force. When incoming pressure overcomes the spring load, the valve opens to relieve excess pressure and to restore desired upstream pressure. In continuous service, as in a pump by-pass system, valve action is full floating. A. W. Cash Valve Manufacturing Corp., 666 East Wabash Avenue, Wabash and Morgan, Decatur 60, Ill.

For more information—Circle 89, inside back cover

ENGINEERING MATERIALS

Ribbed, Embossed Aluminum Sheet

In gages ranging from 0.010 to 0.064 in. and available as both flat and coiled sheet in alloys 1100, 3003, 5050 and 5052, ranging in temper from "0" to H394, applications for this ribbed pattern include storm door kick plates, bus seat backs, garage doors, freezer panels, store fronts, awnings. Maximum width is 48 in. Kaiser Aluminum & Chemical Corp., 1924 Broadway, Oakland 12, Calif.

For more information—Circle 90, inside back cover

Beryllium Alloy Wire

A high conductivity beryllium copper alloy wire is composed of 0.5 percent beryllium, 2.5 percent cobalt and balance copper. With 65 to 70 percent of the conductivity of copper, this wire will resist fatigue from flexing and vibration and withstand higher temperatures.

It comes with a light silverplating which facilitates soldering. This plating also makes it possible to apply the new type insulating materials that require higher curing temperatures than tinned wires can stand. It is available in all fine wire gauges in solid or stranded form. Little Falls Alloys, 194 Caldwell Ave., Paterson, N. J.

For more information—Circle 91, inside back cover

Thermo-plastic Glazing for Safety Applications

A transparent, scratch and abrasion resistant glazing material made of thermosetting resins is said to offer optical and mechanical properties not generally available in either glass or transparent thermo-plastics. CR-39 is suggested for use in such applications as safety goggles, shields, instrument faces, grinding wheel guards, windows for viewing dangerous processes, cab glazing on power shovels and cranes. Homalite Corp., 11-13 Brookside Drive, Wilmington, Del.

For more information—Circle 92, inside back cover

Silicone Rubber Compounds

Two silicone rubber compounds are being produced with mechanical properties which are described as comparing favorably with those of synthetic rubber. Tensile strengths range from 1000 to 2000 psi and tear strengths are 200 to 300 psi. The new compounds are available in the form of sheets, molded parts and fabricated articles. Connecticut Hard Rubber Co., New Haven, Conn.

For more information—Circle 93, inside back cover

Fire Wall Seal Withstands 2000 F Flame

This sealing material is a combination of sponge rubber or other materials encased in fiberglass fabric. Tests indicate the material resists direct flame under 2000 F for 15 min. Types of seals are available which are exceptionally resistant to engine fuels and lubricants and which will retain their flexibility and resilience under wide temperature extremes. Arrowhead Rubber Co., Long Beach, Calif.

For more information—Circle 94, inside back cover

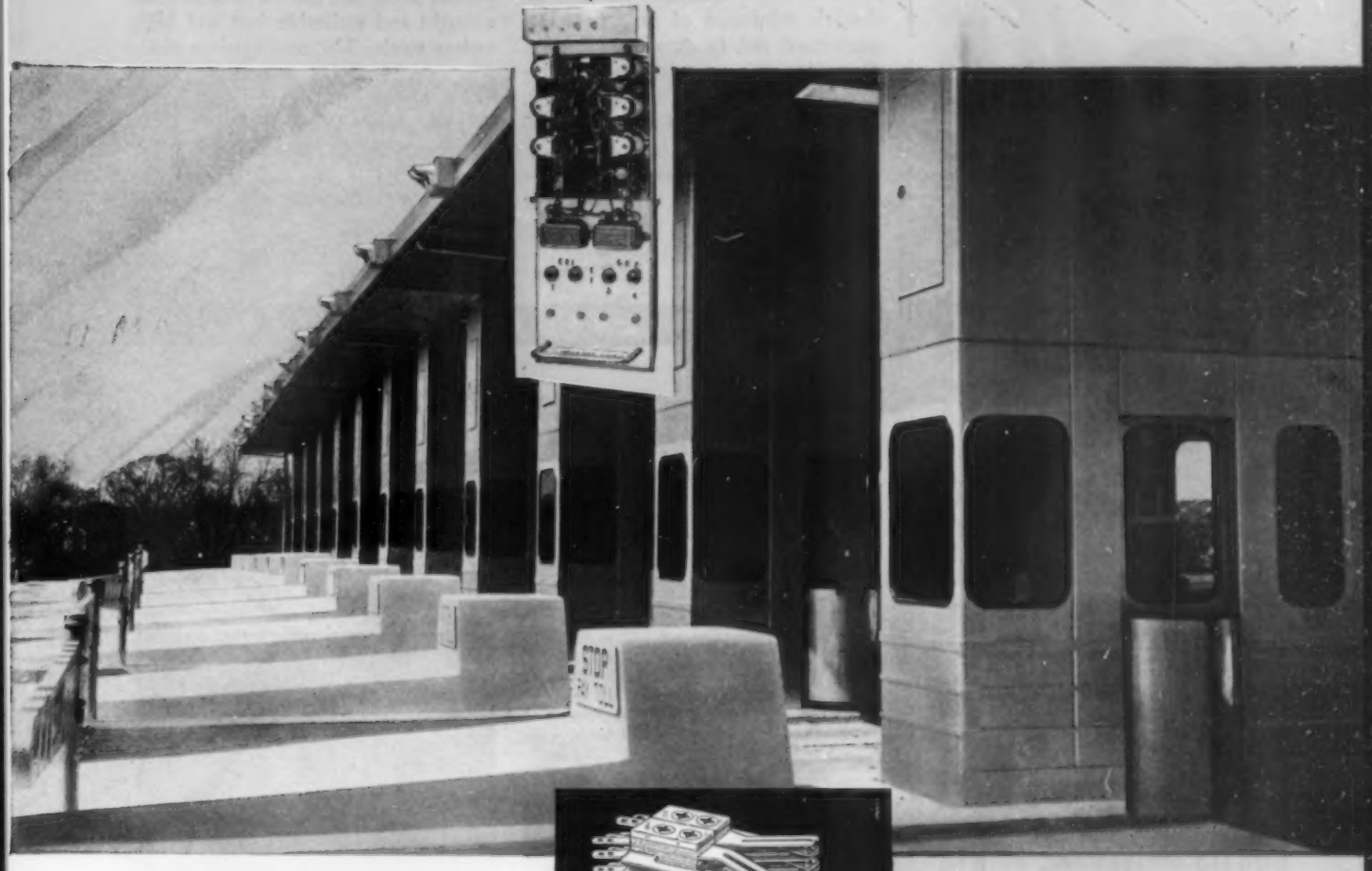
Asbestos Fiber

Asbestos fiber has been made available that is extracted from selected

CLARE
Type J Relays
help count cars ACCURATELY and FAST ...on Jersey's Garden State Parkway

Keeping track of traffic on the Garden State Parkway hour after hour, day after day, is rugged duty for control equipment. Only the most sturdy and precise components can stand the wear and tear.

That's why engineers of Taller & Cooper, Inc., whose toll booths and collection equipment are found on every major American toll facility, chose CLARE TYPE J RELAYS. These relays accurately record the number of vehicles that pass through the Toll Plaza. Their high speed permits accurate readings of automobiles even up to 40 miles per hour.



CLARE RELAYS

FIRST
in the industrial field

For complete data on the Type J and all Clare Relays, write for ENGINEERING DATA BOOK. *A Clare sales engineer is located near you. Call him or write C. P. Clare & Co., 3101 West Pratt Blvd., Chicago 45, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable address:* CLARELAY.

The Type J Relay may have just what YOU want in a relay

SMALL AND LIGHT:
2¼" long; 2¼ oz. (approx.)

LARGE CURRENT CAPACITY:
4 amperes, 150 watts. Twin contact points (palladium) standard.

FAST OPERATE-RELEASE:
1 to 2 milliseconds (Min.) Coils can be provided for time delay on operation, release, or both.

OPERATING VOLTAGE:
Up to 220 volts d-c.

NEW FEATURES:
Independently operating twin contacts minimize contact failure.

Hinge-type armature recently improved to prolong life and increase stability of relay adjustment.

New heavy duty yoke has stainless steel pivot pin with large bearing surface which turns in precisely reamed bearings of non-ferrous material.

Through the years, our trade mark has become a mark of quality that stands for the simplicity, efficiency and dependability of Curtis Universal Joints . . . the Hallmark of the industry.

In a wide range of applications, Curtis Joints offer the designer assurance of long life and trouble-free performance — because they are quality-controlled at each step of manufacture.

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- 14 sizes always in stock
- Fewer parts, simpler construction
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high grade ore by a new technique which is said to fully preserve the inherent characteristics of the original fiber. This material (crocidolite) is completely processed, requiring no further processing and only one pass through a disintegrator to re-establish specification volume after compression during packing and shipment. Fiberization is uniform, and it contains an absolute minimum of dust and grit, guaranteed not to exceed 3 percent. This fiber is particularly suited for blending with short fiber crysotile. Pitnam Industrial Products Co., 608-5 Ave., New York, N. Y.

For more information— Circle 95, inside back cover

Finish For Ferrous Metals

A line of silicate or glass-like protective coatings, which can be fused to any ferrous metal, can be applied by spray, brush or dipping and fired at temperatures from 900 to 1200 F, depending upon the type of finish desired. Suitable surfaces are reported to include sheet and plate as well as cast, wrought and malleable iron and high carbon steels. The new finish is available in a variety of permanent colors and in textures ranging from full matte to high gloss. Allied Porcenell, Inc., 851 S. Market St., Waukegan, Ill.

For more information— Circle 96, inside back cover

ENGINEERING EQUIPMENT

Slide Rule Pencil

This device measures, calculates, writes, has a cursor, detachable straight-edge, eraser, lead chamber, and it clips in the pocket. Said to handle exactly like a conventional slide rule, the new pencil is comparable to a regular mechanical pencil in size and weighs 1 oz. Device Development Co., 226 W. 4 St., New York 14, N. Y.

For more information— Circle 97, inside back cover

Tracing Paper and Cloths

Six tracing papers and cloths have been introduced that are said to provide superior translucency, permanence, uniformity, penciling and erasability. Tests on the three tracing papers show that they are odorless and completely "cured," so that they will not become brittle or lose proper transparency. Negligible leaching occurs after long storage or where drafting tape is applied. The fine-grained surface is processed for accepting pencil lines with strong opacity.

Among the three tracing cloths, the Whitney No. 378, is reported to be the first dual-purpose cloth that accepts both ink and pencil equally well. Ink lines do not chip or flake off, and pencils as hard as 9-H neither "skip" nor damage the surface. Obtainable in blue and white, it is also water repellant, making it impervious to common solvents, spilled liquids, and perspiration stains. Charles Bruning Co., 4700 Montrose Ave., Chicago 41, Ill.

For more information— Circle 98, inside back cover

Automatic-Feed Drawing Pen

The holder of this ruling pen contains an ink cartridge said to hold the equivalent of 55,000 in. of ruled lines. The ink is government-approved India ink.

To fill the nib, the cap is pressed. A concealed feed-tube is activated, re-

PIONEERS IN POWER STEERING
...TURN TO Eastman
PIONEERS IN THE FIELD OF HYDRAULIC HOSE ASSEMBLIES

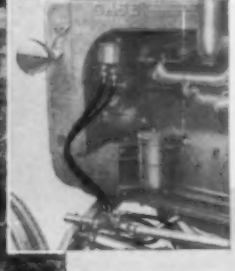
MOVING MOUNTAINS

Designers of this great mountain mover were pioneers in the application of hydraulic power in steering this type of earth moving equipment. Thus, *pioneers in power steering turned to pioneers in Hydraulic Hose Assemblies.* Hydraulic power—applied through Eastman Hydraulic Hose Assemblies to the twin brakes, shown here, wheel this International Model 75 "PAYSCRAPER" over rugged mountain terrain.

MOVING FORESTS

Eastman Hydraulic Hose, operating at 2000 lbs. p.s.i., delivers the power required to steer the rear axle, weighing 11,800 lbs., on this New "Hyster" SC-180 model. Due to heavy, load-balancing counter-weight over this axle, it would be impossible to steer this "King of the Lift Trucks" without hydraulic power when empty. Maximum maneuverability is attained through power steering—moving loads up to 9 tons, like these giants of the forest.

MOVING FIELDS



First tractor to use power steering—the Case "500" Diesel, at work here, uses Eastman "first in the field" Hydraulic Hose Assemblies for 1800 lbs. p.s.i. working pressure. Despite front end weight of 2470 lbs., hydraulic power makes steering almost effortless. Turning over 30 furrows in one "swath," this Case Disc Plow makes fields "move over" 18 feet at a time! Again, J. I. Case, *pioneers in farm machinery* since 1847, chose Eastman, *pioneers in Hydraulic Hose Assemblies.*

SAFEGUARDING INDUSTRY'S *Lifelines of Mobile Power*

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Dept. PE-1, Manitowoc, Wis.

NOTE:
If you wish to be first in your field—come to Eastman—"first in the field" of Hydraulic Hose Assemblies.

WRITE *for Catalog 101 on Eastman Hydraulic Hose Assemblies*

Brute Strength or Delicate Handling of Rotary Power Functions • • •
TWO VANES ARE BETTER THAN ONE
The hydraulically balanced DUAL-VANES in DUDCO Fluid Motors, as contrasted with conventional designs, maintain MULTIPLE AREAS OF CONTACT ON THE CAM RING . . . doubling the number of effective barriers to slippage and power loss. This patented principle is an exclusive DUDCO feature!

DUDCO
FLUID MOTORS

Compact and sturdy, DUDCO DUAL-VANE Fluid Motors operate quietly and smoothly under the most strenuous conditions. They're built to "take it" . . . frequent reversals, rapid accelerations or stalling under load. With DUDCO you get the big advantage of 2000 psi operation at a cost comparable with that of lower pressure equipment.

DUDCO is a big, exciting story for every hydraulics engineer because . . . power losses are minimized and operating efficiency is higher . . . starting torques are high . . . operation is smooth, quiet and exceptionally free from wear or maintenance problems.

On Conveyor systems for agricultural, food processing, mining and other industries, DUDCO DUAL-VANE Fluid Motors provide the extras in performance that save time, money and labor. Operating

the winches on a giant tank retriever and other large mobile equipment calls for high starting torque and the dependable power of DUDCO DUAL-VANE MOTORS.

Write for Bulletin DM-301 fully describing DUDCO DUAL-VANE Fluid Motors today!

DUDCO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1712 EAST NINE MILE ROAD • HAZEL PARK • MICH.

leasing the ink needed to fill the nib. The manufacturer states that use of these pens eliminates stopping work to fill pens from inkwells, and then drying the nibs. Nibs are of rustproof stainless steel. Rule-O-Matic Corp., 38 E. 57 St., New York 22, N. Y.

For more information—
Circle 99, inside back cover

Voltage Regulated D-c Power Supply

This d-c power supply has been designed for general laboratory and production line use and to provide power for low voltage klystrons. It has a wider than usual output range with a "B" supply ranging from 0 to +600 v, 0 to 200 ma, and a "C" supply from 0 to −250 v, 0 to 5 ma. It offers an additional fixed voltage of −250 v, 0 to 50 ma, derived from the "C" supply, and an unregulated 6.3 v, 10 amp, center tapped, a-c filament supply. It will provide klystrons with up to −600 v cathode voltage and an additional 0 to −250 v for the reflector. Higher voltages may be obtained through "stacking" two or more units because none of the supply voltages are grounded to the chassis.

The voltage regulation is only ±¼ v change for both line fluctuations of ±10 per cent and load changes from zero to maximum, except for the variable "C" supply. The latter offers ±¼ v change for line fluctuations with a constant load. Ripple is less than 4 mv. The Type 807 can be furnished to operate from either 115 or 230 v, ac, 50 to 60 cycles per sec, single phase. A panel voltmeter and milliammeter are supplied. Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

For more information—
Circle 100, inside back cover

Resistance Comparator

Developed for the comparison of load or power resistors, this comparator does not use batteries or tubes. It plugs directly in to a 115 or 230 v circuit and is said to require no adjustments of any kind. Its construction permits use on commercial projects, even by unskilled workmen.

Equipped with a 7 in. dia dial, all comparisons are readable to 0.01 per-

cent accuracy. Readings on the instrument are interpreted into percentage of difference in the resistors compared.

The comparator is available in three ranges: 10 to 1000 ohm, 1 to 100 ohm and 1 to 50 ohm. Each model can be used with any standard decade box. R. L. Fearn, 375 S. Main St., Homer City, Pa.

For more information—
Circle 101, inside back cover

Lightweight Regulated Power Supply

A magnetic amplifier-regulated, 28 v, 100 amp power supply recently introduced is tubeless and contains no moving parts other than a cooling fan. Overall dimensions are 25 in. long x 15 in. deep x 15 in. high. Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

For more information—
Circle 102, inside back cover

Square Wave Voltage Calibrator

One problem in the use of an oscilloscope is the calibration of the instrument so that voltage may be read directly from the face of the cathode ray tube. This instrument generates a square wave with a constant frequency of 1 kc per sec and an amplitude which can be continuously varied from 0 to 50 v. A display of this signal on an oscilloscope appears as two parallel horizontal lines. The distance between these two lines is equal to the desired voltage.

The amplitude of any other signal then displayed on the oscilloscope may be read directly in volts by comparison with the calibrator signals. On the other hand, the unknown signal may be displayed first, and by adjusting the calibrator indication to agree exactly with the unknown, the voltage may be read directly from the calibrator dial.

The range of this instrument is covered in nine steps from 0.005 to 50 v, full scale, while the fine adjustment is made by means of a dial. Beckman Instruments, Inc., P. O. Box 296—Station A, Richmond, Calif.

For more information—
Circle 103, inside back cover

These famous Gear Type Motors operate with pressures up to 1500 psi. Available in flange or foot-mounted models, in a complete range of sizes to 52 hp. They feature the exclusive HYDRECO Four Bolt design which places greatest strength in the area of greatest pressure.

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HYDRECO
FLUID MOTORS

You find the answers to so many problems in the wide experience of HYDRECO engineers . . . especially where a function involves rotary motion. Powering the sweeper or the snow blower on municipal equipment, driving conveyor belts on trenchers, or shaking walnuts out of the trees at harvest time . . . these are but a few of hundreds of money-saving operations HYDRECO Fluid Motors are called upon to perform.

HYDRECO Fluid Motors, with their high starting torque, instant reversibility, and capacity for handling rugged and seemingly impossible assignments, are the natural choice of design engineers. HYDRECO dependability stems from the fundamentally sound "Pressure-Balanced" design, unmatched craftsmanship and the "know-how" of thousands of outstanding hydraulic applications.

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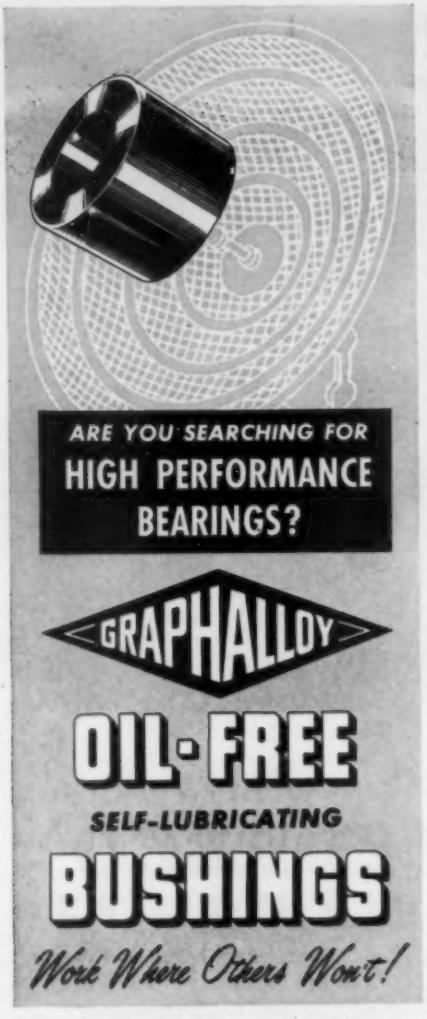

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GRAPHALLOY materials are also in wide use for oil-free, self-lubricating piston rings, seal rings, thrust washers, friction discs, pump vanes, etc.

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

Power Transmission—Manual, 100 pp, is divided into about 12 sections, such as: stock sheave dimensions, selection guide, tabular data on available drives according to speed ratings, design engineering data, tabular data on available belts, horsepower ratings of belts. Photographs, exploded views, engineering drawings, curves are used to illustrate information presented.

The stock selection tables in the front of this manual are said to make it possible to select sheaves and belts in not more than three minutes. Service factors for various types of service loads and conditions are provided. These factors are used to adjust anticipated drive speeds and, in turn, the following tables of stock equipment are based on revolutions per minute, as the basis of selection.

Engineering aids are also provided for designing special drive equipment. Formulae permit determination of pitch length, center to center distance, sheave diameters and other design elements. Worthington Corporation, Harrison, New Jersey.

Circle 104, inside back cover

Investment Casting—Brochure VR-471, 11 pp. Originally developed for this company's investment casting sales force, this brochure is being made generally available.

The process is described and illustrated and there is an explanation of how a typical part is produced by investment casting. Limitations of the investment casting process are also discussed, including what to avoid in designing, size and weight of parts, tolerances and quantities of parts that make the process practical. Concluding the comparison of investment casting with other production methods is an explanation of the tooling, patterns and samples necessary to produce parts by the investment casting process. Vascoloy-Ramet Corp., Waukegan, Ill.

Circle 105, inside back cover

Split Ball Bearings—Catalogue 54, 24 pp, describes complete line of ball bearings. Gives load and speed ratings, design data, dimensions. Lines shown are single and double row ball bearing bushings in extra-thin section; fully split heavy duty pillow blocks; fully split, heavy duty ball and roller bearings; thin section instrument bearings in torque tube dimensions for precision applications, and heavy duty metric series ball bearings.

Information on the various design possibilities afforded by the use of fractured race bearings is also included. Split Ballbearing Corp., Lebanon, N. H.

Circle 106, inside back cover

Refractory-Fiber Felt—Folder, 6 pp. This refractory-fiber felt is for service to 2000 F, as heat insulation, filter medium for hot gases and liquids, sound control in the presence of intense heat, refractory packing and fill. Data provided includes its K factor, sound absorption qualities, chemical and thermal stability, densities, sizes and thicknesses. Johns-Manville, 22 E. 40 St., New York 16, N. Y.

Circle 107, inside back cover

Clutch-Coupling Units—Catalog 102, 20 pp. Over-running clutches for overrunning, backstopping and indexing applications are included. Photographs, application drawings, and engineering and specification data for each clutch of the six standard lines are provided. Other sections give specific information on selection, installation and maintenance. Formsprag Co., 23601 Hoover Road, Van Dyke, Mich.

Circle 108, inside back cover

Temperature Control—Bulletin 105, 2 pp, describes dual temperature controls, incorporating two independent electric switches for operation up to 1800° F. Burling Instrument Co., 16 River Road, Chatham, N. J.

Circle 109, inside back cover

Selenium Rectifiers and Diodes—Bulletin SR-1A, 8 pp. Data on construction, applications, types, ratings,

HYDRAULICS FOR MOBILE EQUIPMENT

VOL. 2

Mobile Equipment News

VICKERS INCORPORATED, DETROIT, MICHIGAN

IMPROVES PERFORMANCE • CUTS COSTS

NO. 4

VICKERS® VT16 PUMP NOW AVAILABLE FOR HYDRAULIC POWER STEERING OF TRUCKS AND MATERIALS HANDLING VEHICLES

The Vickers Series VT16 pump is used more widely than all other makes combined for the power steering of automobiles. It is now available for the first time for the hydraulic power steering of trucks and materials handling vehicles. It has all the characteristics important to this service and is used in a separate hydraulic circuit for steering only.

COMPLETE PACKAGE

Series VT16 has integral volume control valve and relief valve . . . also an integral oil reservoir. This is a complete hydraulic power package for steering.

SIMPLIFIED INSTALLATION

This compact and complete power package is easily and quickly installed. All you need to do is bolt it on, make two hydraulic connections, and couple the power.

LONGER PUMP LIFE

The exclusive Vickers "Hydraulic Balance" eliminates pressure-induced bearing loads and the consequent wear. These lighter bearing loads mean much longer bearing and pump life.

NO LOAD STARTING

At rest and normal starting speeds, the sliding vanes are retracted; only after engine fires do vanes extend and pumping begin.

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Series VT16 Vickers Pump with integral volume control and relief valves and oil reservoir. For hydraulic power steering.

HIGH OPERATING EFFICIENCY

The vane type construction, hydraulic balance and automatic maintenance of optimum running clearances enable these pumps to deliver more oil with less power. This high operating efficiency is maintained throughout the long pump life.

Series VT17 Vickers Pump is similar to the VT 16 except that it does not include the oil reservoir.

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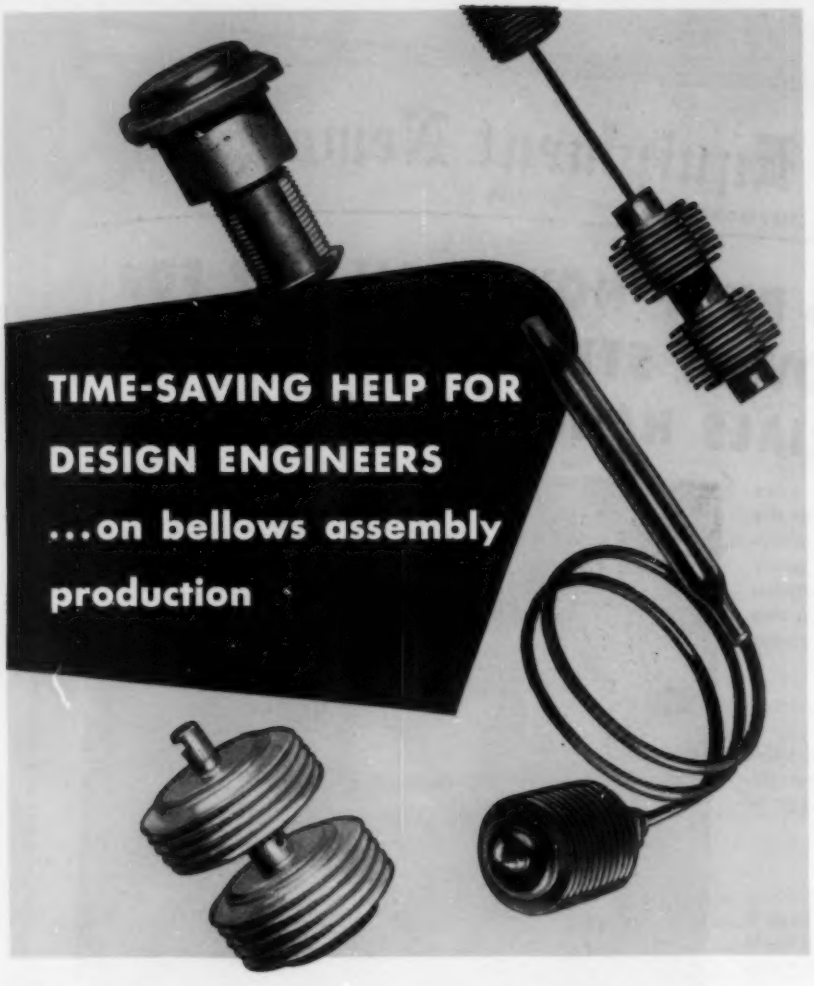
EFFORTLESS • POSITIVE • SHOCKLESS

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



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reference curves, specifications, d-c characteristics. Also contains charts and graphs. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Circle 110, inside back cover

High Velocity Oil Burners—Bulletin 107, 54 pp. Contains information on operating principles, applications, dimensions and output data. Thermal Research & Engineering Corp., Conshohocken, Pa.

Circle 111, inside back cover

Relays—Catalog 54, 8 pp, describes and illustrates electrical relays. Data tables and dimensionsal drawings included, Magnecraft Electric Co., 1450 W. Van Buren St., Chicago 7, Ill.

Circle 112, inside back cover

Jewel Bearings—Catalog, 4 pp, indicates available tolerances (within 0.00005 in. on ID), presents a hardness comparison chart (Mohs' and Knoop). Includes various types of jewels. Swiss American Jewel Bearings Co., 32-30 58 St., Woodside 2, N. Y.

Circle 113, inside back cover

Graphite Centrifugal Pumps—Bulletin No. 854, 8 pp, covers standard models of these pumps, ranging from 25 to 2000 gpm at 20 to 100 ft head. Also includes detailed parts drawings, accurate dimensional drawings and performance charts for each model. In addition, chemical and physical properties of graphite used are listed. Falls Industries, Inc., 31829 Aurora Road, Solon, Ohio.

Circle 114, inside back cover

Die Casting—Booklet, 28 pp, discusses this production method as it affects product design, machining requirements and surface finish. Zinc, aluminum, magnesium and copper-base die casting alloys are discussed, including advantages and limitations with regard to cost, dimensional accuracy, surface finish, strength and machinability. Chart lists for each alloy, its ASTM and SAE designations, composition by weight, properties and constants in the as-cast condition. American Zinc Institute, Inc., 60 E. 42 St., New York 17, N. Y.

Circle 115, inside back cover

Measurement and Control—Catalog, 24 pp, describes synchros, servo motors, gyroscopes, power supplies, posi-

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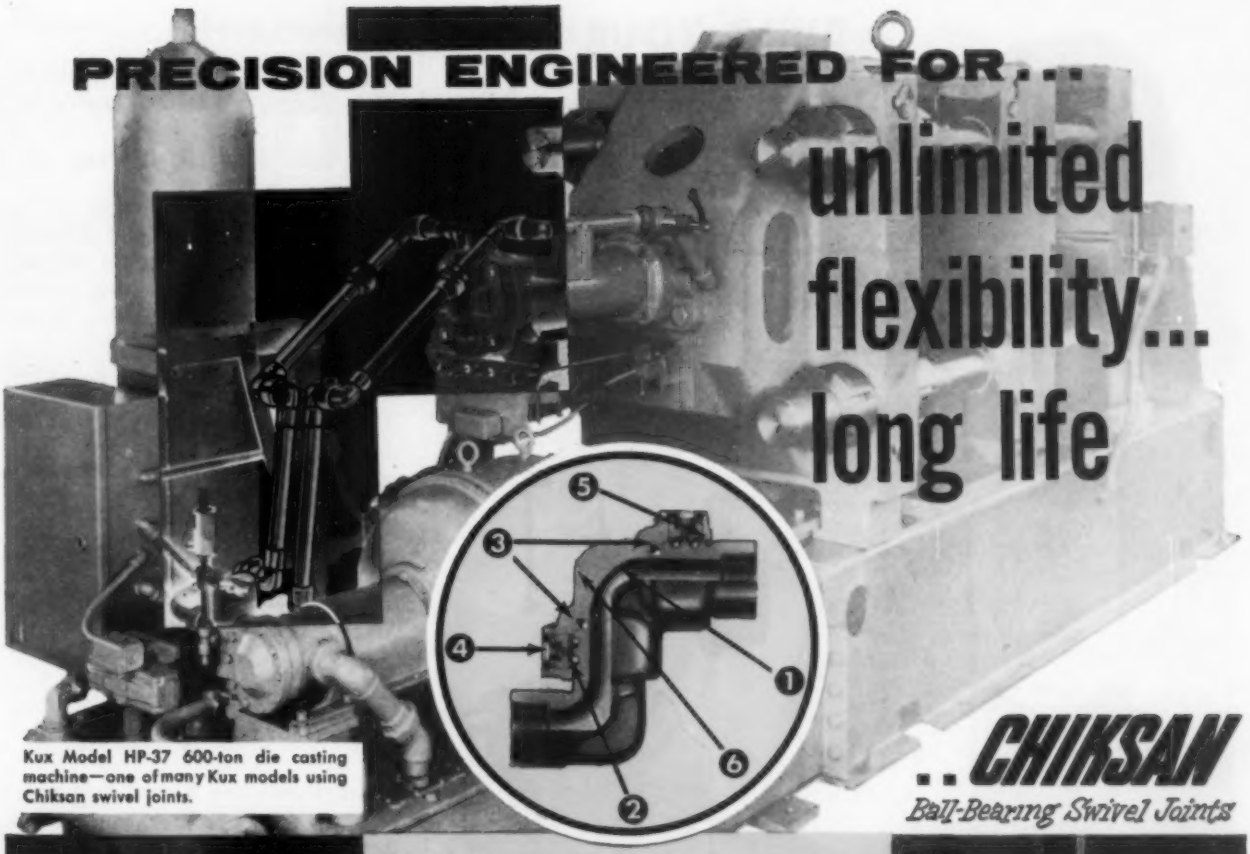
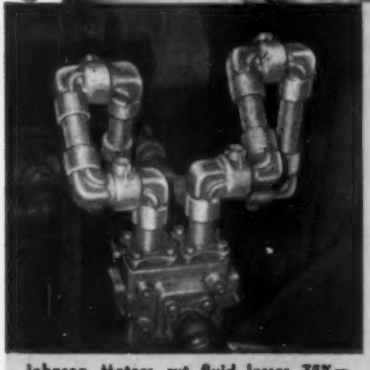
unlimited flexibility... long life



Kux Model HP-37 600-ton die casting machine—one of many Kux models using Chiksan swivel joints.

...CHIKSAN
Ball-Bearing Swivel Joints



Johnson Motors cut fluid losses 75%—setting-up time 75% with Chiksan joints on their 48 die-casting machines.

Chiksan high-pressure swivel joints permit compact assembly for operation in limited space on injection molding equipment.

1. Smooth flow radii for minimum flow restriction.
2. 2 rows of ball bearings handle thrust and radial loads.
3. Balanced packing units for specific services.
4. Spherical radius ball plug for uninterrupted ball race.
5. Grease retainer provides extra protection for ball race area.
6. Wall thicknesses provide maximum strength throughout.

CHIKSAN Ball Bearing Swivel Joints turn with full 360° rotation in 1, 2, and 3 planes, handling air, hydraulics, fuels, oils, water and other fluids.

There are over 1,000 different types, styles and sizes for pressures and services from 28" vacuum to 15,000 psi and for temperature ranges from minus 75° F. to a plus 500° F. Packing materials have been designed for each specific service.

Wherever unlimited flexibility is required in your research, design and engineering of new equipment for modern industry—CHIKSAN will help you find the solution.

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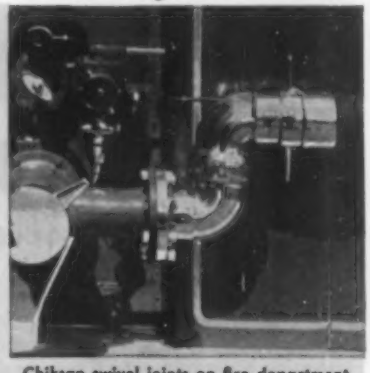
The Flow of Enterprise Relies on

CHIKSAN
Ball-Bearing Swivel Joints



Chiksan swivel joints on fire department trucks provide increased hose flexibility and save on hose wear.

Chiksan high-pressure swivel joints provide flexibility and eliminate danger of ruptured steam lines on platen presses.

CHIKSAN COMPANY • BREA, CALIFORNIA • Chicago 3, Illinois • Newark 2, New Jersey

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Co., Brea, Calif.; Newark 2, N. J. • Chiksan of Canada Ltd., Edmonton, Alta.

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By incorporating the Bijur System into your designs, you can offer substantial operating economies which progressive users now demand. For example, in the metalworking field 75% of machinery users prefer "built-in" automatic lubrication on the machines they buy.

Costly hand lubrication is eliminated.

Production time is saved because machines are oiled while in operation.

Bijur Automatic Lubrication is the best friend a bearing ever had. Every bearing is automatically fed a metered shot of oil at predetermined intervals.

Inaccessible bearings that require regular lubrication are never neglected.

There can be no problem of work spoilage or bearing headaches caused by over lubrication.

Leading machine builders have standardized on Bijur for a quarter of a century. Bijur puts the accent on engineering design – to satisfy the specific requirements of your machines.

Our engineers can show you how to build increased dependability into your machines, whether they are in production or still on the board.

0-4

Write for literature and engineering data.

8370

BIJUR LUBRICATING CORPORATION

Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

Catalogs and Bulletins.....continued

tion indicators, amplifiers. Doelcam Corp., Soldiers Field Road, Boston 35, Mass.

Circle 116, inside back cover

Pressure Transmitter–Bulletin A-713, 2 pp, gives data on principles of operation. It is illustrated with cutaway view and dimensional diagram. Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.

Circle 117, inside back cover

Thrust Washers–Bulletin, 2 pp, describes nylon washers for fhp motors and provides dimensions and prices. Cosmo Plastics Co., 3239 W. 14 St., Cleveland, Ohio.

Circle 118, inside back cover

Vacuum-Melted Metals and Alloys–Technical Bulletin VM-100, 16 pp, gives data on vacuum-melted metals and alloys. General Electric Co., Detroit, Mich.

Circle 119, inside back cover

Pillow Blocks and Flange Bearings–Bulletin PB-54, 34 pp, contains sketches, photographs and engineering drawings together with complete specifications for bore sizes from ½ through 1¼ in. Tann Corp., Detroit, Mich.

Circle 120, inside back cover

Air Motors and Valves–Bulletin SP 50, 28 pp, has 75 illustrations and 27 specifications charts. Bellows Co., 222 W. Market St., Akron, Ohio.

Circle 121, inside back cover

Pressure Vessel Connections and Manways–Catalog 10-53, 70 pp, data on connections, manways, necks, nozzles. Lenape Hydraulic Pressing & Forging Co., Dept. 138, W. Chester, Pa.

Circle 122, inside back cover

Lubricators–Booklet, 4 pp, contains curves, engineering drawings, tables and descriptions of oil fog lubrication systems and equipment. C. A. Norgren Co., 3428 S. Elati St., Englewood, Colo.

Circle 123, inside back cover

Six-Cylinder Industrial Engines–Bulletin, 4 pp, provides power curves, engine specifications. Willys Motors Inc., 1320 N. Cove Road, Toledo, Ohio.

Circle 124, inside back cover

Speed-Regulated Motor–Leaflet SC-5-754, 2 pp, includes dimensioned

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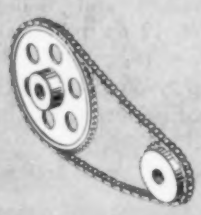

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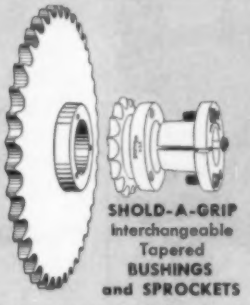

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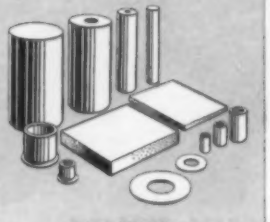

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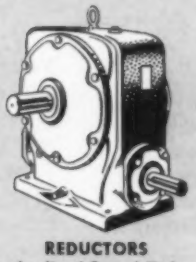

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outline drawings; a specification tabulation covering both electrical and physical characteristics, a performance graph showing efficiency, governed speed, input amperes and output watts plotted against torque output. Dalmotor Co., 1362 Clay St., Santa Clara, Calif.

Circle 125, inside back cover

Stainless Steel Valves—Booklet, 15 pp. Engineering drawings, tables detail construction, dimensions, characteristics of globe and stop valves. Associated Valve and Engineering Co., 1150 W. Marquette Road, Chicago 21, Ill.

Circle 126, inside back cover

Insulated Terminals and Splices—Bulletin YAE 54, 12 pp, provides information on tin-plated copper, nylon-insulated, compression-installed connectors. Burndy Engineering Co. Inc., Norwalk, Conn.

Circle 127, inside back cover

Time Delay Relay—Bulletin TD500, 2 pp, describes relays which are motor-driven and provide controlled time delay periods adjustable over a wide range. A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn.

Circle 128, inside back cover

Voltage Stabilizers—Catalog 4-260, 166 pp, describes performance characteristics of units regulating incoming line voltage to within ½ percent in 1/20 sec. Raytheon Mfg. Co., Dept. 6120-PR, Waltham 54, Mass.

Circle 129, inside back cover

Shock and Vibration Mounts—Brochure, 4 pp, has brief descriptions of standard isolators, including miniature mounts for electronic gear in aircraft, shock mounts for mobile and shipboard packaging and leveling units. Also lists technical articles on various aspects of shock and vibration. Barry Corp., Dept. P, 1000 Pleasant St., Watertown, Mass.

Circle 130, inside back cover

Roller Gear Drives—Catalog 105, 20 pp, describes line of gear drives for high-speed precision indexing of automatic production machinery. Tables on load ratings and dimensions for components only and housed units are given as well as data and instructions for calculation of loads, designing an

installation and selection of a drive. Ferguson Machine & Tool Co., P. O. Box 191, St. Louis 21, Mo.

Circle 131, inside back cover

Servo Motors—Catalog 5, 4 pp., contains drawings, tables and descriptions devoted to servo motors, tachometer-generators. G-M Laboratories, Inc., 4300 N. Knox Ave., Chicago 41, Ill.

Circle 132, inside back cover

Air Filters—Bulletin 135, 4 pp, describes filtering units designed for stationary and portable engines, and compressors. American Air Filter Co. Inc., Louisville 8, Ky.

Circle 133, inside back cover

Electric Motors—Booklet, 11 pp, presents data on available motor types, dimensions, ratings, control arrangements. Allis-Chalmers Mfg. Co., 866 S. 70th St., Milwaukee 1, Wis.

Circle 134, inside back cover

Magnetic Separators—Catalog 17, 16 pp, provides information on installation, technical data, specifications and available sizes of plate magnets, magnetic humps, grate magnets, pipeline traps, ferrous cleaners, micro-magnetic separators, magnetic pulleys, drums, sheet fanners, sweepers, hoppers and slurry drums. Eriez Mfg. Co., Erie, Pa.

Circle 135, inside back cover

Knives, Ways, Wear Plates—Catalog 22, 57 pp, describes all products for five industries: machinery, metalworking, iron and steel, pulp and paper, woodworking. Photographs, drawings and tables detail slitter knives, spacers, shear blades, ways, gibs, wear plates, work rest blades and tools. Ohio Knife Co., Dept. B-35, Cincinnati 23, Ohio.

Circle 136, inside back cover

Plastic Closures—File folder describes threaded and non-threaded caps and plugs for safeguarding products in process, storage and transit. Included are price lists for over 100 sizes of the five standardized designs used to protect tubing, fittings, valves, hydraulic components and numerous machined parts. Protective Closures Co. Inc., 2207 Elmwood Ave., Buffalo 23, N. Y.

Circle 137, inside back cover

Roll Shafts—Bulletin, 2 pp, is fourth of a series on aspects of industrial roll design. This report discusses com-

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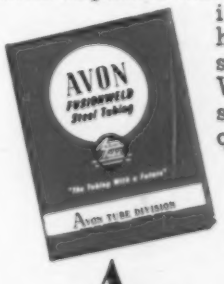

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bined torsion and bending in roll shafts. Rodney Hunt Machine Co., Orange, Mass.

Circle 138, inside back cover

Geared Joint—Bulletin 548, 2 pp, discusses a geared joint that will transmit up to 3500 in-lb in any angle up to 360 deg. A typical installation on a remote valve control application is shown. Drawings give dimensions on all three sizes and information on the size of rigid rod or flexible shaft that can be used on each joint. Stow Mfg. Co., 443 State St., Binghamton, N. Y.

Circle 139, inside back cover

Steam and Air Traps—Bulletin, 4 pp, describes low pressure steam traps for 15 and 35 psi service. Angle, offset, offset swivel, straightway, inverted bucket and float and thermostatic traps, packless and modulating valves, air vents and connecting spuds of various matching lengths are included. C. E. Squires Co., 18502 Syracuse Ave., Cleveland 10, Ohio.

Circle 140, inside back cover

Air-Operated Clutch—Bulletin A-634, 4 pp, gives data on air control and release valves. Includes clutch sizes, dimensions, bore sizes, weights and list prices. Dodge Mfg. Co., Mishawaka, Ind.

Circle 141, inside back cover

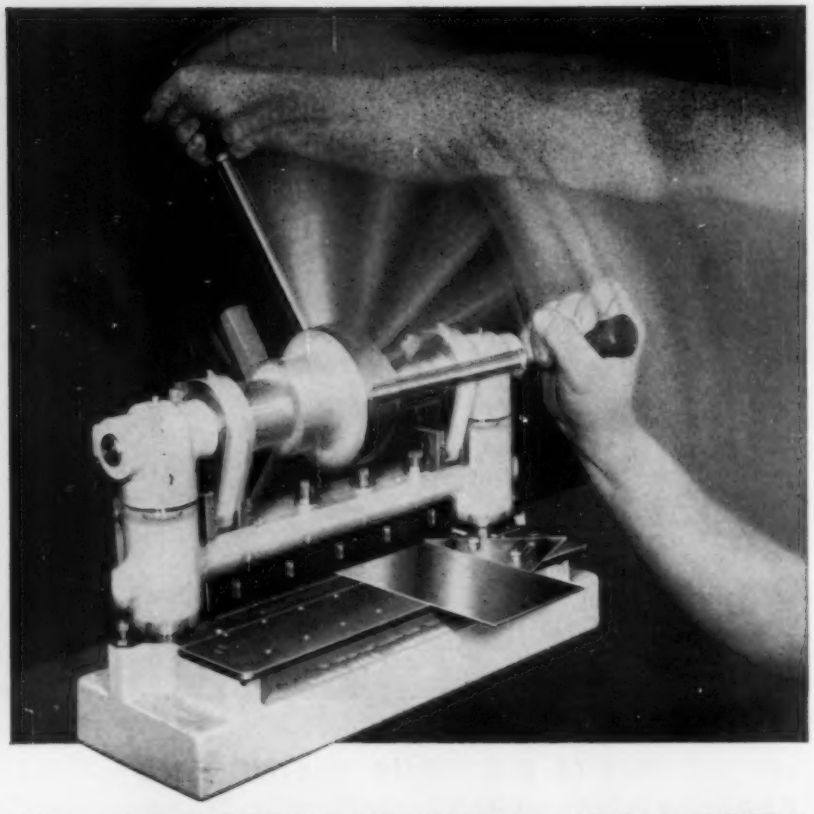
Fluid Power Equipment—Bulletin 10051-D, 12 pp, describes pumps, motors, transmissions, cylinders and valves. Details on a new electric-hydraulic servo control system for pumps and transmissions of up to 150 hp are included. Oilgear Co., 1571A W. Pierce St., Milwaukee 4, Wis.

Circle 142, inside back cover

Cam Clutches—Catalog C11-54A, 8 pp, has general information on cam clutches, including cutaway views, operating functions, line drawings. Specifications, installation procedures and lubrication information are also included. Morse Chain Co., 7601 Central Ave., Detroit 10, Mich.

Circle 143, inside back cover

Rotary, Multipole Switches—Catalog, 12 pp, contains complete wiring diagrams and contact charts for voltmeter, ammeter and voltmeter-ammeter switches. Detailed drawings are included, with handle and panel-mounting data, physical dimensions,



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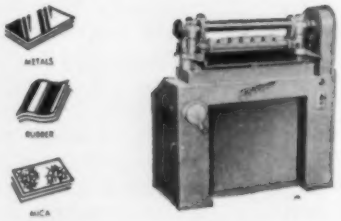

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special switch information and electrical ratings. Electro Switch Corp., Weymouth 88, Mass.

Circle 144, inside back cover

Electrical Relays—Catalog, 44 pp. Illustrates and describes standard relays which are carried in stock, and also suggests some modifications. Details include characteristics, schematics and dimensions. Midgets, circuit controls, special purpose, radio and high frequency, aircraft relays and contactors are all included. Leach Relay Co., 5915 Avalon Blvd., Los Angeles 3, Calif.

Circle 145, inside back cover

Counting Machines—Catalog, 8 pp, contains descriptions of the various models, numerous applications for varied industrial uses. F. B. Redington Co., 109 S. Sangamon St., Chicago 7, Ill.

Circle 146, inside back cover

Overhead Conveyor Trolley—Booklet, 20 pp, includes application and maintenance information and a description of attachments commonly used. There are 12 illustrations of typical overhead trolley installations. Link Belt Co., 307 N. Michigan Ave., Chicago 1, Ill.

Circle 147, inside back cover

Air-Powered Solenoid Valve—Bulletin AV300R, 8 pp, shows installation photographs, and describes in detail all parts and functions of this air control unit, including dimensional drawings and specification data. Schematic wiring diagrams are also shown. Bellows Co., 222 W. Market St., Akron, Ohio.

Circle 148, inside back cover

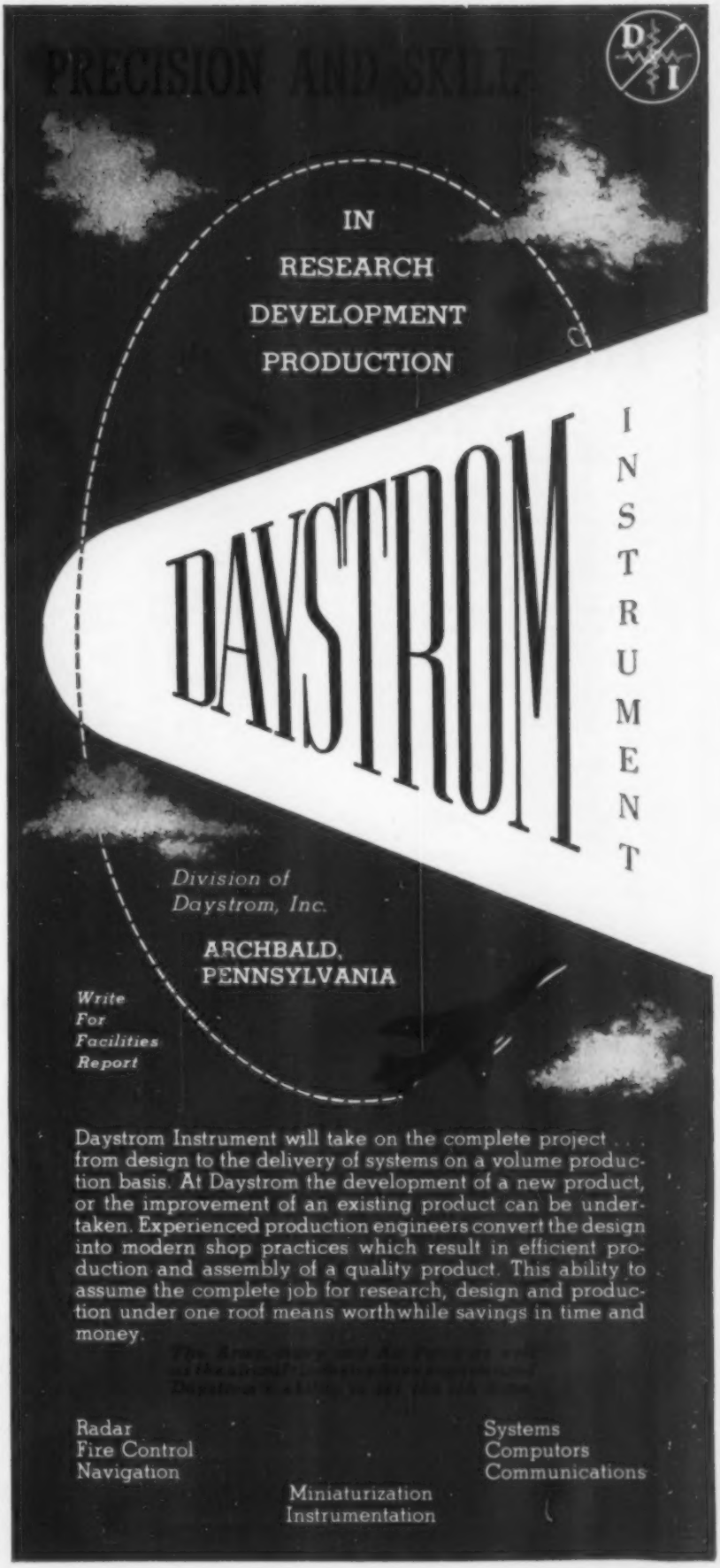
Liquid Polymer Cold Casting Compounds—Bulletin, 4 pp. Several trial formulations and properties of cold casting compounds are described. Thiokol Chemical Corp., 780 N. Clinton Ave., Trenton 7, N. J.

Circle 149, inside back cover

Reproduction Materials—Book, 36 pp, describes variety of materials and applications available to users of the diazo-type (whiteprint) reproduction process. Tecnifax Corp., 195 Appleton St., Holyoke, Mass.

Circle 150, inside back cover

Shock and Vibration Isolators—Bulletin 541, 8 pp, gives load ranges of these mounts, along with shock and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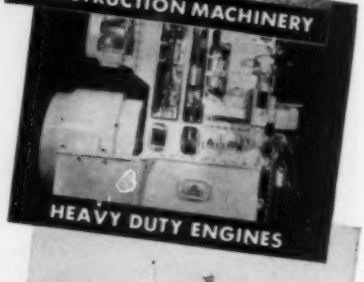

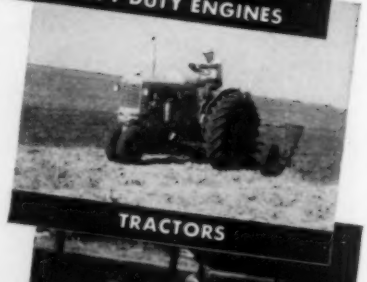

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vibration transmission characteristics. Specification data is also included. Barry Corp., Dept. 541, 1000 Pleasant St., Watertown, Mass.

Circle 151, inside back cover

Plastic Pipe, Fittings and Valves—Bulletin 80-A, 6 pp, gives general properties of multi-polymer rigid plastic pipe, together with chemical resistance tables, standard sizes, pressures and prices of pipe, fittings and diaphragm valves. American Hard Rubber Co., 93 Worth St., New York 13, N. Y.

Circle 152, inside back cover

Silencers, Snubbers—Bulletins 265, 255, 260, 261, 270, 275, 280. Data on design, capacities, characteristics of silencing equipment for steam vents, safety valves, turbines is provided. Burgess-Manning Co., 1203 Dragon St., Dallas, Texas.

Circle 153, inside back cover

Electrical Switch—Bulletin, 2 pp, describes snap-action switch designed for appliances and automotive machinery. Cherry Electrical Products Corp., 3080 Skokie Valley Road, Highland Park, Ill.

Circle 154, inside back cover

Chain Coupling—Bulletin, 1 pp. Cross-sectional drawing and tabular data on shaft couplings. Browning Mfg. Co., Maysville, Ky.

Circle 155, inside back cover

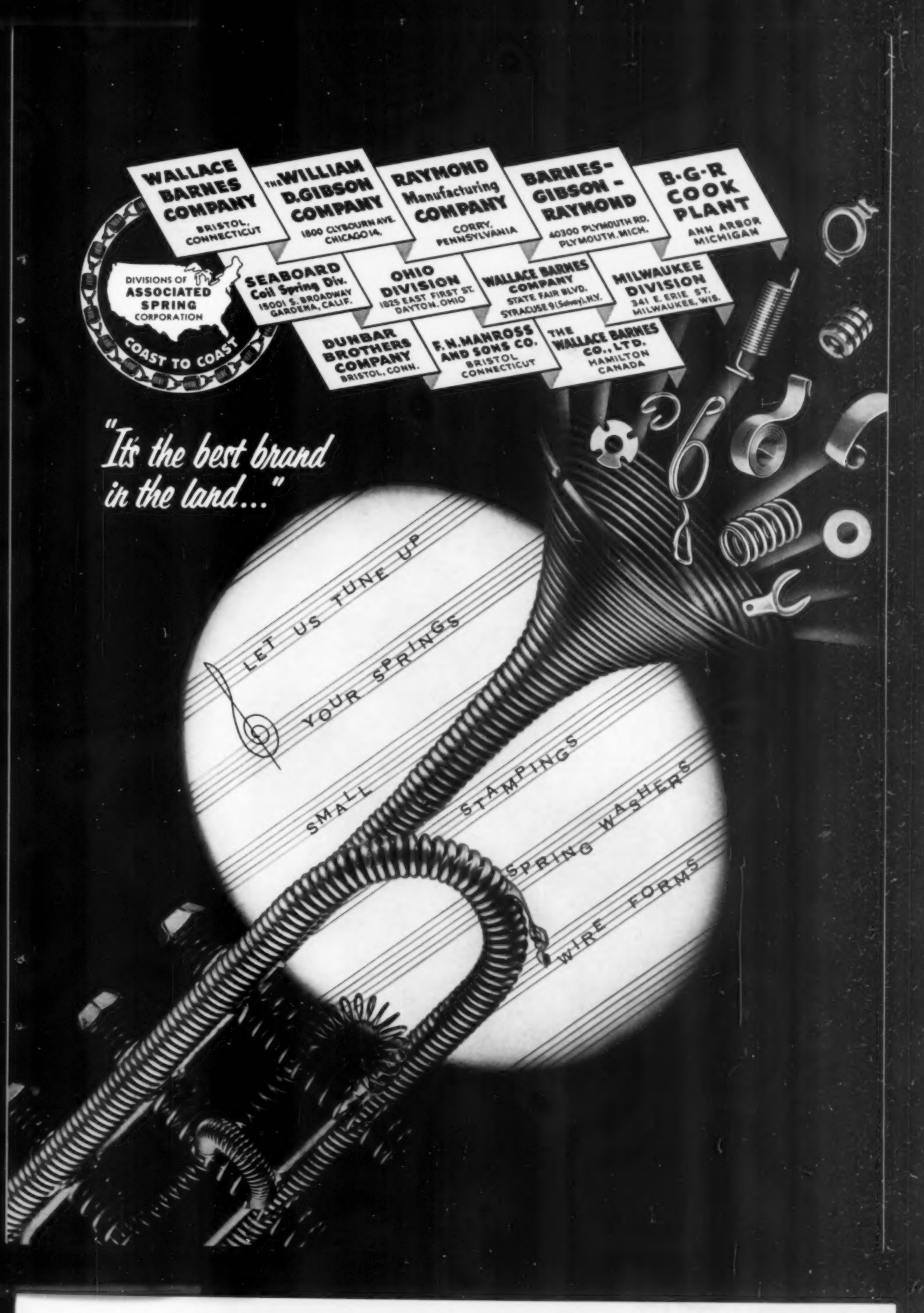
Packing, Gaskets—Bulletin 410, 6 pp, describes O-ring, V-packings, tape, gaskets, shapes, rod, sheet, cylinders molded of Teflon. Micromold Products Corp., 11 Centre Pl., Yonkers, N. Y.

Circle 156, inside back cover

Stainless Steels—Catalog, 20 pp, describes basic No. 20 alloy and the No. 20-Cb columbium-stabilized analysis. These are sulphuric acid resisting. Physical and mechanical properties are given as well as a full listing of the various forms and shapes available. Carpenter Steel Co., Union, N. J.

Circle 157, inside back cover

Power Transmission Equipment—Catalog GC-101-B, 19 pp, describes single and multiple groove and variable pitch sheaves, V-belts, couplings, paper pulleys, keystock, hubs for split bushings, set collars, frictions, cast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Circle 158, inside back cover

Chrome-Nickel Steels—Catalog, 13 pp, describes No. 158, a case hardening steel, and Carpenter No. 5-317, either a hard-tempering or tough-tempering steel, depending upon heat treatment. Analysis, physical properties, working instructions and stock sizes available are provided. Carpenter Steel Co., Reading, Pa.

Circle 159, inside back cover

Wire Rope Assemblies—Catalog 5201, 21 pp, describes assemblies consisting of units of flexible wire rope with permanently attached fittings of various types and sizes. These controls are used as a part of machinery and equipment or for slings and hoists. Macwhyte Co., Kenosha, Wis.

Circle 160, inside back cover

Aluminum Designation System—Chart includes both old and new designations for easy conversion and describes in detail the workings of the new four-digit index system. Peter A. Frasse and Co., Inc., 17 Grand St., New York 13, N. Y.

Circle 161, inside back cover

Lock Nuts—Booklet, 8 pp, contains tables, descriptions of various types of these fastenings. MacLean-Fogg Lock Nut Co., 55 N. Wolcutt Ave., Chicago 40, Ill.

Circle 162, inside back cover

Wafer Capacitors—Catalog, 2 pp, gives complete descriptions, special design factors, voltages, dissipation factors, leakage resistance, temperature vs. voltage derating factor, absorption and capacitance variation vs. frequency and temperature of the capacitors. Aircraft-Marine Products, Inc., 2100 Paxton St., Harrisburg, Pa.

Circle 163, inside back cover

Cork Products—Bulletin S55, 4 pp, lists the physical properties and uses of natural cork and cork compositions. SAE, ASTM and government specifications are shown. Sheet sizes and thicknesses are given. Dodge Cork Co., Inc., Lancaster, Pa.

Circle 164, inside back cover

Pilot-Type Relief Valves—Catalog sheets illustrate use, operation and

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low cost housings suffice

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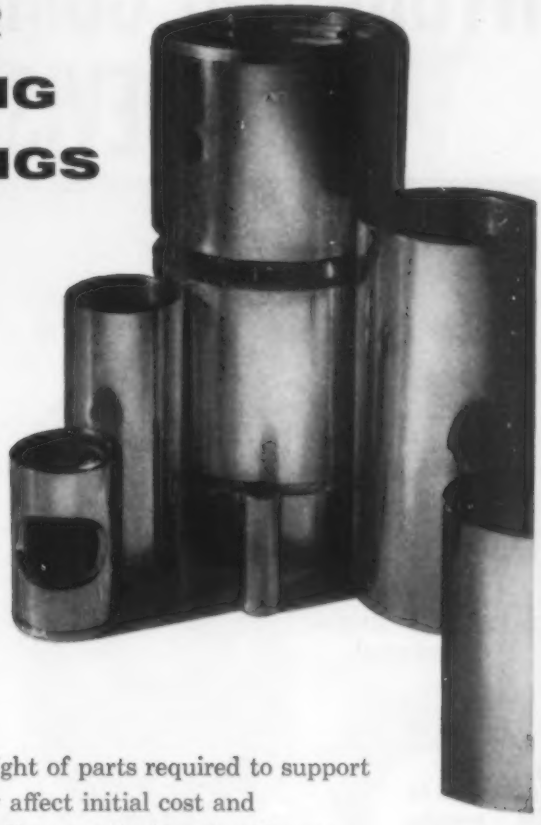
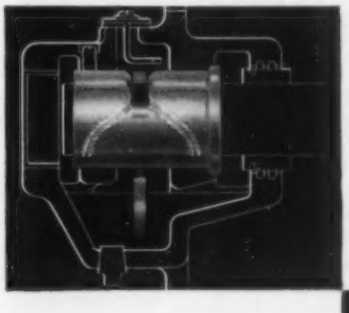


The size and weight of parts required to support a bearing sharply affect initial cost and production costs. Because the Bunting Bronze Bearing is much smaller in diameter than other types of bearings required for similar applications, the supporting parts are lighter and lower in cost.

You can easily learn what economies can result from your use of Bunting Bronze Bearings. There is a Bunting engineer near you for consultation. Or write our Product Engineering Department at Toledo.



The weight of parts required to support a bearing varies directly as the square of the outside diameter of the bearing. The Bunting Bronze Bearing is much smaller in outside diameter than other types.

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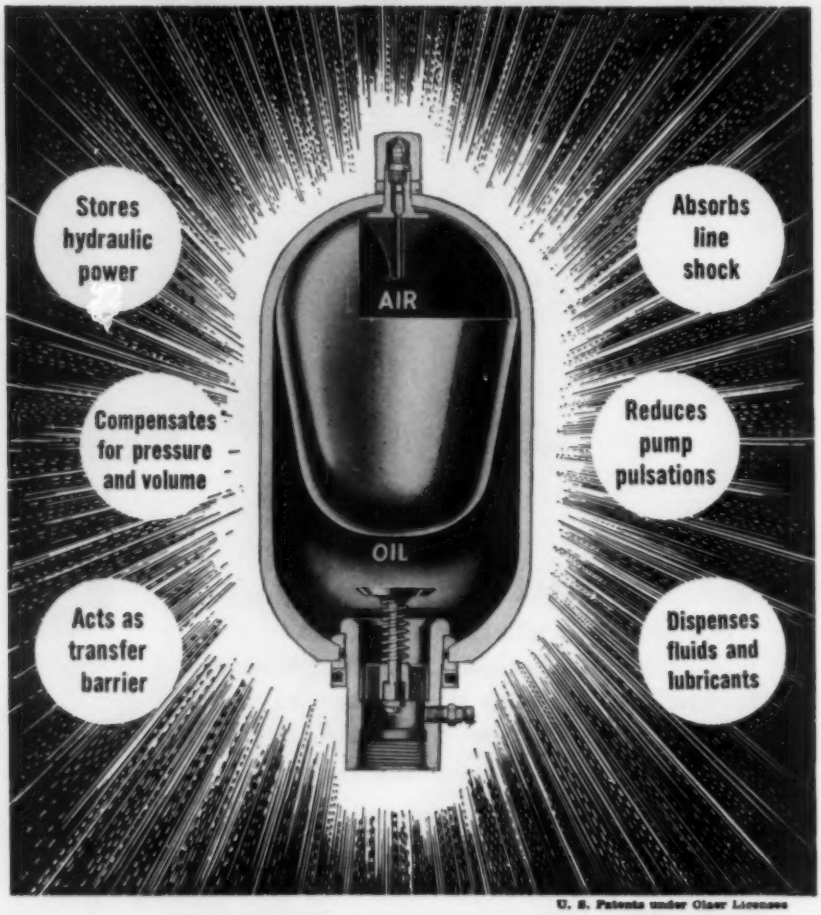

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design of these valves. Cross sectional drawings, a typical installation diagram and a table showing operating performance are provided. Fluid Controls, Inc., 1284 N. Center St., Mentor, Ohio.

Circle 165, inside back cover

Direct-Drive Fan Motors—Bulletin, 2 pp, describes 1/12, 1/8 and 1/6 hp motors, having integral mounts for four or six fan blades. Electric Motors & Specialties, Inc., King and Hamsher St., Garrett, Ind.

Circle 166, inside back cover

Stainless Steel Gate Valves—Bulletin 55 G, 4 pp. Schematic drawings of the various valves, a section on design factors, a discussion of construction materials and standards are all included. A table of the major stainless alloys, giving their designations and applications, is also provided. Cooper Alloy Foundry Co., Hillside, N. J.

Circle 167, inside back cover

Hydraulic Cylinders—Bulletin 54-68, 8 pp, has cutaway photographs, installation drawings for each of five cylinder mounting styles available. Chart provides all cylinder dimensions for standard bore sizes from 1½ to 6 in. Vickers, Inc., 1400 Oakman Blvd, Detroit 32, Mich.

Circle 168, inside back cover

Fluid Couplings—Bulletin 144-D, 14 pp, has drawings, curves, tabular data on characteristics, capacities, construction of these couplings. Twin Disc Clutch Co., Dept. DS., Racine, Wisc.

Circle 169, inside back cover

Extruded Plastics—Brochure, 4 pp, illustrates over 50 different cross sections typical of the limitless variety of shapes, rods, strips and tubes which can be custom extruded from thermoplastics. General specifications of the various types of extrusions are given. Also included is a guide to the comparison and selection of ten thermoplastic materials used for extrusions. Anchor Plastics Co., Inc., 36-36 36 St., Long Island City 6, N. Y.

Circle 170, inside back cover

Torque Motors—Catalog El-3A, 25 pp, lists physical characteristics, dimensional drawings and performance curves and provides electrical specifications in appropriate groupings for induction units ranging from 1000 to

1/6 hp, for single, two, and three-phase operation, 15 to 400 cycles. Electric Indicator Co., Inc., Springdale, Conn.

Circle 171, inside back cover

Molded and Extruded Rubber and Plastics—Catalog 786, 16 pp, contains specifications, terms, definitions, performance characteristics, tolerances and tables of properties available in common rubber and plastics compounds. General Tire & Rubber Co. Wabash, Ind.

Circle 172, inside back cover

Powder Steel Parts—Folder, 4 pp, provides data on sintered parts, said to have ductility and strength in the range of low-carbon steel. Amplex Chrysler Corp., P. O. Box 2718, Detroit 31, Mich.

Circle 173, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Speed Reducers—Catalog 120, 24 pp, has revised rating tables of their herringbone and spiral bevel-helical speed reducers. Along with tables, there are instructions for choosing speed reducer needed. Brad Foote Gear Works, Inc., 1309 S. Cicero Ave., Cicero 50, Ill.

Abrasive Wheels—Booklet, 40 pp, is entitled, "Why Do Abrasive Wheels Fail? (Sometimes)". Explains why abrasive wheels fail and how to prevent this failure and also tells how abrasive wheels cut. Wallace Tube Co., 1304 Diversey Parkway, Chicago 14, Ill.

Lead Treated Steels—Booklet, 8 pp. Tables and graphs compare properties of these steels and others. Copperweld Steel Co., Dept. 18, Warren, Ohio.

Connection Diagrams for Industrial Controls—Publication 51, 148 pp, provides diagrams for the wiring of a wide variety of electrical equipment into control systems. Included are circuits for switches, coils, starters, contactors, drum controllers, relays, transformers. Product illustrations also included. Furnas Electric Co., Batavia, Ill.

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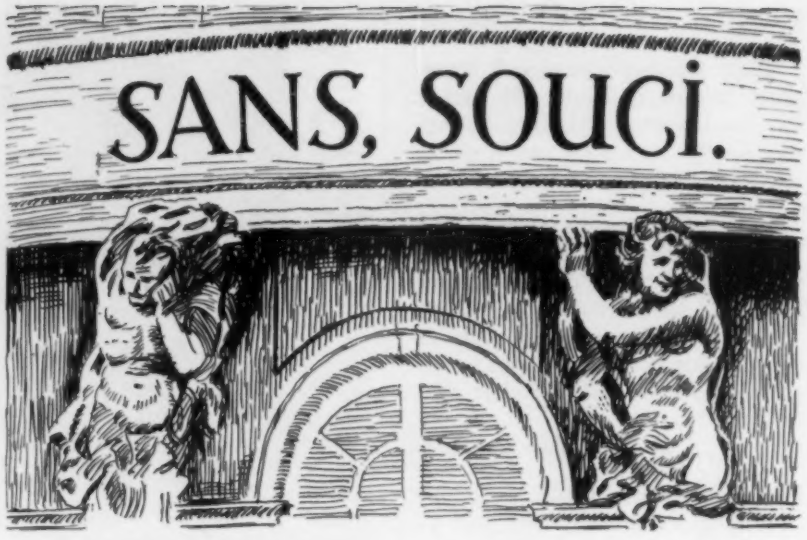

Ad Libbing by the Editor

There are always days that stand out above all others. In my life one of those was a day that I spent with Dr. Karl Arnstein while the Macon was being built at the Goodyear Zeppelin plant. The Acron had already been commissioned. Dr. Arnstein was very patient and took the time to show me around the plant and explain the construction features on the Macon, and then took me to lunch. In the course of this we had a very interesting discussion concerning the provisions that were made for using the airship as a mother ship for planes.

It is all a matter of history now that the Acron and Macon broke to pieces. I have not seen the report of the investigation that was made but I will always believe that the basic cause of the failure was related to the decision made after the design had been almost completed to make provisions for the "mother ship" idea. In any event, in my estimation those two failures do not cast any reflection on Dr. Arnstein's ability as designer of air ships. He had already designed more than 70 ships and none of them failed structurally in normal service.

Whether it was the circumstances of the occasion or some other reason, I do not know, but in any event, Dr. Arnstein and I got into some very interesting discussion at lunch. He having been an engineering professor in Germany, and I having been an engineering professor, it was but natural that we should get into a discussion about teaching and engineering education. In the course of this, Dr. Arnstein came up with a theory that is not new. He said:

"If a man knows his subject thoroughly he will be able to explain the problems in simple language without resorting to complicated explanations and mathematical relationships that cannot be understood. I have always noticed that the best teachers use only simple words and that what they are saying is easily understood."

Any man who has served on committees, and that means just about every one of us, has often run across the individual who always wanted to make a complicated problem out of a simple addition. This type of individual waits until after the problem has been presented and general agreement on its solution has been reached. Then he gets the floor, looks around slowly and with a sad expression, usually begins with these words:

"Now gentlemen, don't be mislead. On the face of it, this seems like an extremely simple problem. But in effect, that is not so. If you study this thoroughly, the way I have, you will find that there are a great number of factors that enter into its solution....." That is about the way it begins and then it goes on ad infinitum, the speaker doing everything possible to create the impression that only his superior intellect was able to solve the weird complications of this simplest of problems.

I am sure that if a gentleman of that type were endowed with a knowledge of the calculus and were he to be asked how much is two plus two, the

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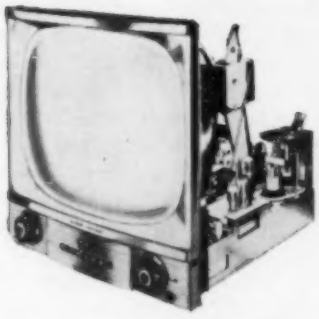

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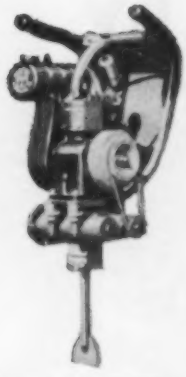

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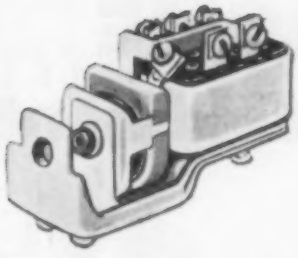

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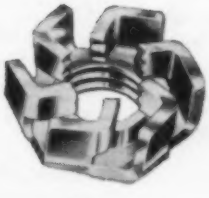
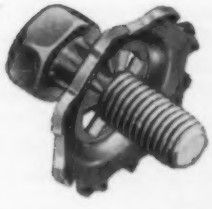


Locknuts



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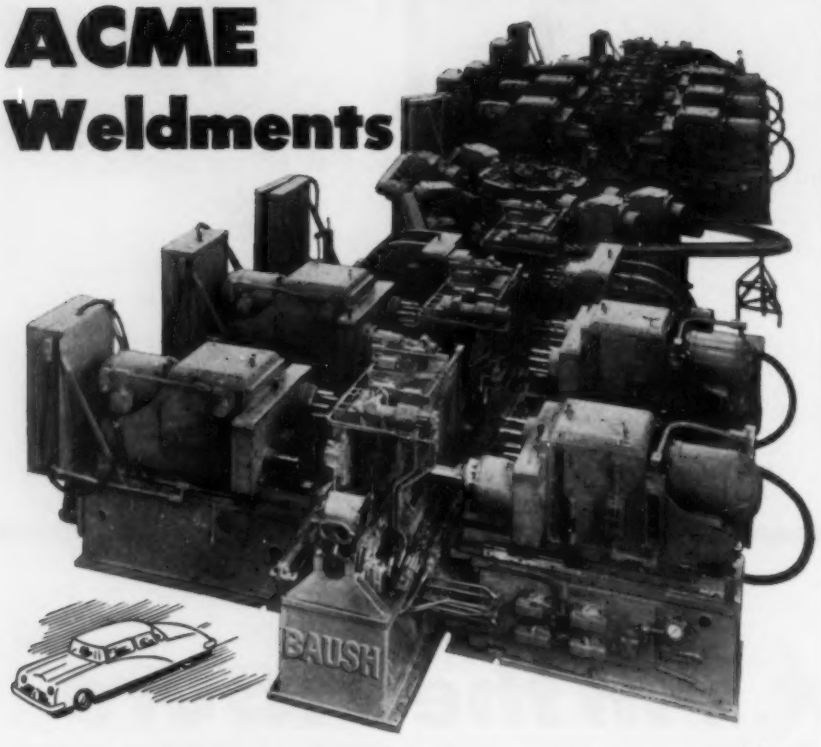

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answer would be extremely interesting. I am sure it would be that it is equal to the integral of xdx between the limits of 1 and 3. To be sure, he would be correct. But why resort to the realms of calculus for the answer to the most elementary arithmetical problem? It is this same type of individual who naturally must make a three hour meeting out of something that can be decided in five minutes.

I have often noticed that the real big men in industry are not the ones who make a long discussion out of a minor question that has an obvious answer. The leaders of industry are usually men who make decisions without quibbling. So don't be a quibbler, be like a leader of industry.

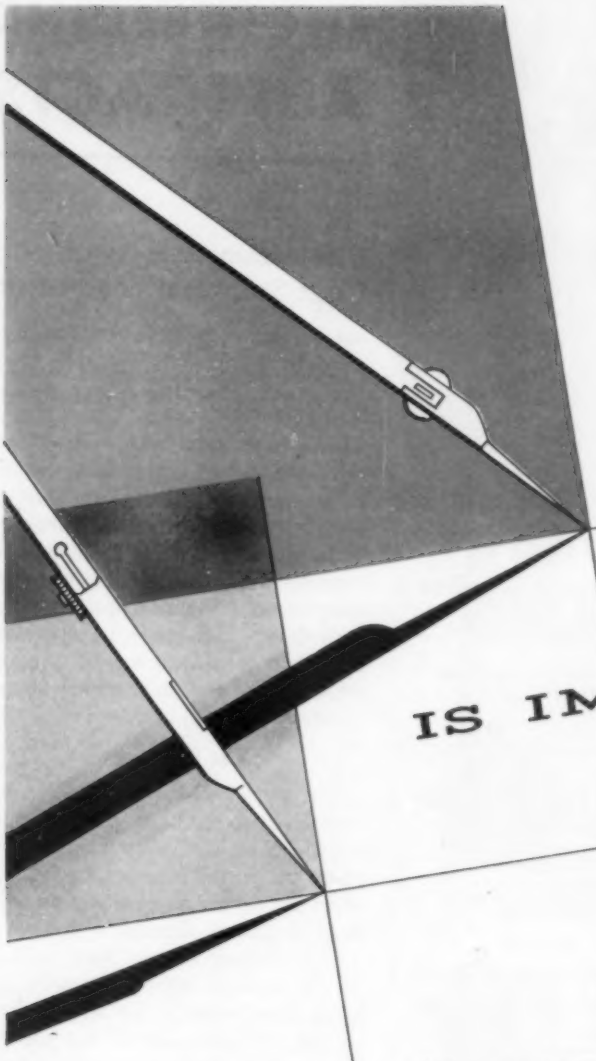
Of course not all leaders of industry speak to the point. Indeed, there are quite a few who love conversation, especially outside of business hours. One of my good friends, I will call him Eddy, was that kind of a man. He told me about his gardener.

"You know George, that gardener of mine, he is a most interesting fellow to talk to. Every Saturday morning I have been stopping to have a word with him. He can tell one story after another, knows half the people in town, can call every rose by its name and can describe all the common diseases of dogs.

"That man is a wonderful talker and had me so interested that I didn't tumble to it for a couple of weeks that I was paying him two dollars an hour just for the privilege of hearing him talk."

The other side of the picture is the silent individual who speaks only in one letter words and only a few at a time. The Calvin Coolidge type. Which reminds me of a press conference with the late F.D.R. When he posed to the whole group this question, "What power do I have that no other past-president did not have?", one of the reporters spoke up and said, "Mr. President, you forcibly remind me of the fact that you certainly have a power of speech that Calvin Coolidge didn't have."

The old saying that talk is cheap is often all wrong. Whether it be a board meeting, an engineers' committee meeting or just listening to the gardener, talk by the hour can be mighty expensive. And when put down in type it can be boring by the inch. So, I'll stop right now.—G. F. N.



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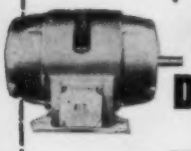

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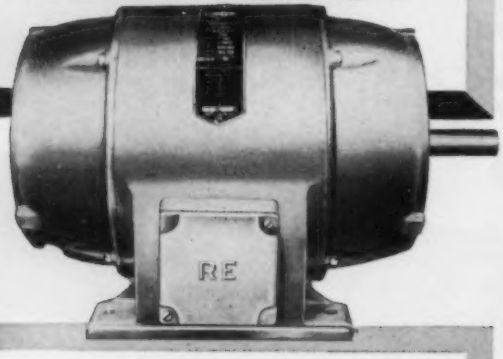
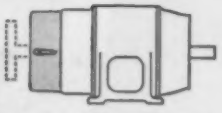
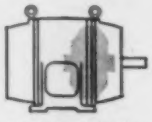
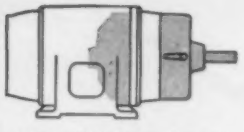




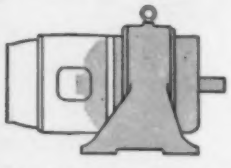
Motor with Reuland "Through Shaft" magnetic brake



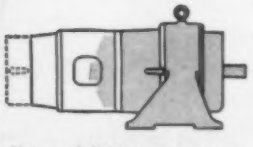
Motor with internal fluid coupling



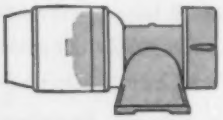
Motor with fluid coupling and brake on output shaft



Motor with fluid coupling and helical gear reducer



Motor with fluid coupling, output shaft brake and helical gear reducer (second brake may also be added)



Motor with fluid coupling, right-angle worm reducer and brake

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ENGINEERING ABSTRACTS

Fabrication Aspects of Large Structural Components

Abstracted from "Fabrication Aspects of Large Structural Components," by H. V. Schwalenberg, North American Aviation, Inc., *Aeronautical Engineering Review,* November 1954.

The aircraft industry has recognized the trend toward large forgings in airframe structure, the desirability of eliminating details, and the economic advantages that may be possible in increasing the size and quality of forged components. The principal forms of such large, high-strength aluminum alloy parts considered are die forgings, routed grids, and taper-milled or machine-sculptured plate.

Die Forgings

The considerable publicity that has been given to the heavy press program as sponsored by the Air Force causes most of us to think first of die forgings when the design specifies an unusually large structural element.

Four forging presses, two each of 35,000- and 50,000-ton capacity, are being constructed in the initial phase of this program. Much has already been written about the potentialities of these presses in regard to possible web thicknesses, draft angles, fillet radii, minimum weight, net or precision forgings. However, from the standpoint of practical design criteria, all of this discussion must be considered to be purely theoretical. It will require at least a year of operation to determine the actual capabilities and limitations of the heavy press program.

Following is a hypothetical example to illustrate the potential economic advantages of these presses. The following figures could apply to aircraft placed in production within the last two years. Assuming a model contained 342 light alloy forgings, the average part would undergo twelve machining operations, amounting to 4.4 hr, for a total of 1,505 machining hours per plane. If precision forgings, as yet undeveloped, could have been used, they would have reduced this

machining time by 25 per cent—a saving of 377 hr at $5.00 per hour, or $1,885 per airplane. This would amount to approximately $1,000,000 on a 500 plane contract.

Routed Grids

Grids are a comparatively recent development in air-frame structure. Stresswise, they provide for densification of surface structure to absorb and distribute concentrated loads. Sandwiched between skins to provide the necessary meat, their most common application is in outer-wing panels and in dive brake doors.

Experience with grids has proved that routing produces a part of less weight than a die forging because of the elimination of draft and that closer tolerances can be maintained. In addition, the overall cost of a routed grid is from 10 to 25 per cent less than for a forging, exclusive of tooling. The cost ratio of tooling is approximately 1 for a routed grid to 10 for a forged grid. The first grid that was used on an N.A.A. air frame cost $550 when routed from plate to finished tolerances. A forging of the part would have required an investment of $30,000 in dies, and the forging would have cost $700 exclusive of finish machining.

A comparative cost analysis of grids versus extruded hat section stringers, straps, and doublers revealed that routing grids from plate stock was the most economical method of fabricating these components. This conclusion was based on savings in weight and the elimination of details and hidden costs, all of which were not possible by any other means.

Form-Die Quench Operation

The key to the successful contouring of routed grids is the form-die quench process whereby the part is heat treated, contoured, and stress relieved in one continuous operation. In the initial phase of the form-die quench cycle, the part is placed in a heat-treat furnace and heated to a specified, closely controlled temperature. The part is held at that temperature until complete and even heating of the metal has been achieved. The heated part is then removed from the furnace and transferred as rapidly as possible to the lower member of a closely mated forming die anchored to the base of the press. The amount of

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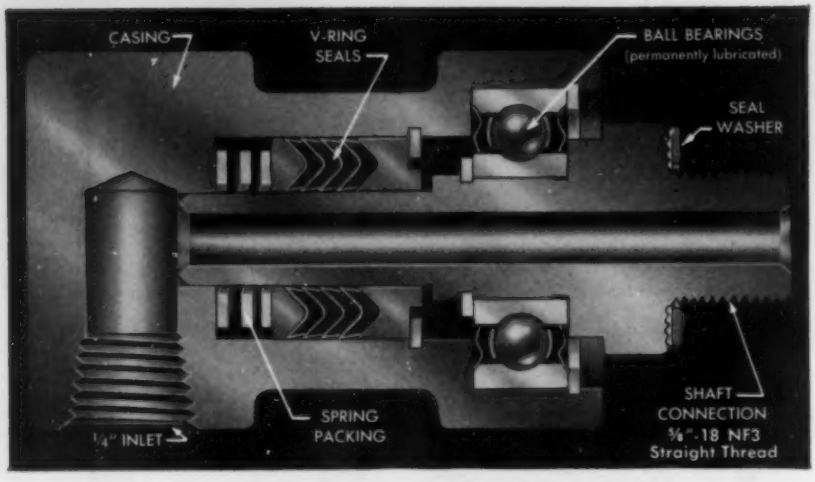

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temperature drop-off during the transfer is very critical and this operation demands teamwork and coordination. The upper die member, attached to the press platen, immediately descends and simultaneously forms and cools the part by metallic conduction through the relatively cold die surfaces. As the form dies constitute a large mass of metal, the die surfaces remain cool during a production run of parts made from thin-gage material. In form-die quenching heavy sections, dies are cooled by circulating water through cored out cavities below and through die surfaces. Residual stresses and spring back in the part are entirely eliminated, as form-die quenching stretches the metal in all directions in fine increments. At heat-treat temperature, the metal expands uniformly in all directions as the natural consequence of elevated temperature. A permanent stretch or deformation of the metal is achieved by subjecting the expanded metal to high forming pressures and maintaining pressures of equal magnitude throughout the forming operation. A short period at dwell prevents the metal from contracting while cooling. It has been necessary to apply pressures in excess of 7,000 lb per sq in. to restrict 1 in. thick material between the smooth surfaces of the Kirksite form dies. The per cent of stretch introduced in the metal by form-die quenching is proportional to the coefficient of thermal expansion of the alloy at the processing temperature. Therefore, when preparing the blank or routed part, it is necessary to reduce it in size from standard measure by approximately eleven thousandths per inch. This reduction can be accomplished by photographic method.

Taper-Milled or Machine-Sculptured Plate

The skepticism with which many designers and production men originally viewed machine-tapered and sculptured skins now seems to have been unwarranted. Taper milling and sculpturing of large sheet was a radical deviation from custom and was seriously questioned on the basis of expense. On the first Sabres there was a total of twelve of these machined skins. The prototype wing skins were vendor produced at a cost of $900 each. Since then this cost has progressively diminished to about $10 per part through

increased know-how and machine and tooling refinement. Our latest standard machine time for 12 taper-milled skins on the F-86D model is 11 hr, or approximately $55 per air frame.

The operations involved in the manufacture of this type of machine-tapered and sculptured skin require the use of a converted large bed planer-mill. This conversion is accomplished by mounting vertically, on the cross rail of the mill, high-speed motors on swivel or universal saddles. These motors, ranging from 30 to 100 hp, and with spindle speeds up to 3,600 rpm, utilize fly-type, single-tooth cutters. For forward, straight-line, full-length taper milling, a cutter of 10 in. dia is used. Table feeds range from 90 to 120 in. per min. However, 4, 6 or 8 in. dia, single-tooth cutters are used at slower table and cross rail feeds for the more complex milling around lands and islands. The material is held down by vacuum to a plate having compound sine features either spanwise or chordwise, or both. Finished sculpture-milled skins will vary in thickness from 0.250 to 0.040 inch.

The mild contouring of tapered or sculptured skins used between spars of the wing box section can be easily accomplished on the hydraulic press brake, using a channel rubber die and a bull-nose punch.

The initial justification for taper milling, lay, primarily, in the possible saving of weight in comparison to a build-up assembly. However, cost alone would now be sufficient justification. For example, the cost difference between dimpling a conventional sheet metal wing assembly or cut countersinking for rivets in a tapered and sculptured sheet is more than the present cost of the milling operation alone. The prestressed hot forming process has shown considerable success in forming large integrally stiffened wing panels with heavy root sections.

The desired contour results from the yielding of the material at elevated temperature induced by using restrained in overformed condition while heated to a temperature in the precipitation aging range for aluminum alloys. The part on the fixture in the over-contoured condition is placed in an oven. Program controllers are used to control the temperature in the furnace at the heavy and light ends of the part to bring them up to soak-

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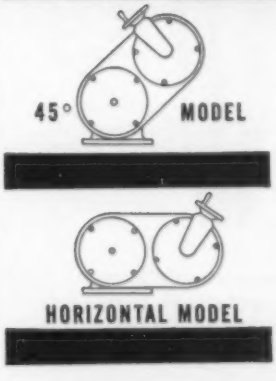

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ing temperature as rapidly as possible, yet have both arrive at the soaking temperature at the same time. A soaking period of 1½ hr at 270 deg plus or minus 5 deg is normally used. The fixture with part is then rolled out of the oven into the quenching position and water is immediately sprayed onto the fixture and concave side of the part. The quenching rapidly cools the part and fixture for handling and limits the time at elevated temperature of the part.

An exaggeration of approximately eight times the desired contour is required for prestressed hot forming present production starts. Any warpage of the part due to machining influences the results obtained from prestressed hot forming. However, this may be conpensated for by the length of time the stressed part is held at temperature. This control will come from the experience of observant personnel with the process.

Experience to date has convinced us that various other methods of preparing large integral wing skins or similar parts, such as casting, forging, rolling and extruding cannot compete with the machine-sculptured type of structure for all-around efficiency. At the same time, the extensive use of this type of structure should be approached with caution where large production quotas are required, as availability of machine time must always be taken into consideration. The machine time and subsequent cost are factors whose importance can be expected to increase as new models are conceived. It would be only logical to assume that the increase in size, speed, and gross weight of projected aircraft would certainly require larger, heavier, and perhaps more complex integral structures than those confronting us at the present time.

Selected Papers from ASM Metal Congress, Chicago, Ill., Nov. 1-4, 1954

"Tensile and Impact Properties of Low Carbon Martensites," C. C. Busby, and H. W. Paxton, Metals Research Lab., Carnegie Institute of Technology, Pittsburgh, Pa.; and M. F. Hawkes, Quality Engineering Lab., U. S. Naval Ammunition Dept., Hawaii.

The mechanical properties of thirty-eight low carbon martensites (0.11 to 0.28 per cent Carbon) in the as-

quenched and quenched and tempered condition were examined. All tempering was done at 100 C (212 F). It was found that the ductility as measured by reduction of area and elongation was greater at all tensile strengths from 180,000 to 260,000 psi than the average of higher carbon steels (0.3 to 0.5 per cent Carbon) quenched and tempered to comparable strengths. Brine quenching gave better properties than oil quenching. The yield strength was comparatively low. The yield-tensile ratio was about 0.7 in the quenched and tempered condition; this could be increased to any value up to 1.0 by a suitable strain aging treatment. The several alloying elements added to obtain the requisite hardenability had no appreciable effect on tensile properties. They did, however, markedly change the impact behavior of the material. Strain aging adversely affected the impact properties of the materials.

"Elevated Temperature Properties of Ductile Cast Irons," Charles R. Wilks, Metallurgist, Norman A. Matthews, Asst. Chief Metallurgist, and R. Wayne Kraft, Jr., Metallurgist, American Brake Shoe Co., Mahwah, N. J.

Creep and stress rupture properties are presented for three types of ductile cast iron over the temperature range of 800 to 1,200 F (425 to 650 C); the familiar standard ferritic and pearlitic grades (60-45-15 and 80-60-03 respectively) and a high alloy austenitic type. Tensile properties at room and elevated temperatures are included along with growth tests. The superior growth and scaling characteristics of the standard ductile irons in comparison with grey irons, together with enhanced creep properties comparable to low carbon steel over the applicable temperature range, suggest wide utility for the ductile irons for elevated temperature service. Markedly higher hot strength at 1,000 F (540 C) and above can be obtained with the high alloy austenitic grade.

"Strength of Wrought Zirconium-Base Binary Alloys at 1,800 to 2,200 F," H. A. Saller, J. T. Stacy, and S. W. Porembka, Battelle Memorial Institute, Columbus, Ohio.

The effects of binary additions of chromium, columbium, molybdenum, tantalum, tungsten, and vanadium on the workability, hardness, and high-

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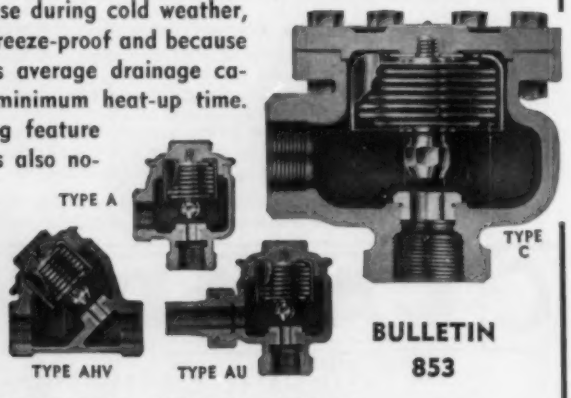

BULLETIN 853

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temperature strength of zirconium were investigated. Alloys of tantalum or tungsten were the most easily worked. At 1,600 F, maximum hardness was obtained with a tungsten addition. Metals of Group 6 were more effective strengtheners than metals of Group 5, tungsten being the most effective strengthener for zirconium at 1,800 to 2,200 F. The 100-hr creep-rupture strength at 1,800 F of a zirconium–8 wt per cent tungsten alloy was 1,700 psi. None of the alloys studied were superior in strength to Inconel or Type 310 stainless steel throughout the range from 1,800 to 2,200 Fahrenheit.

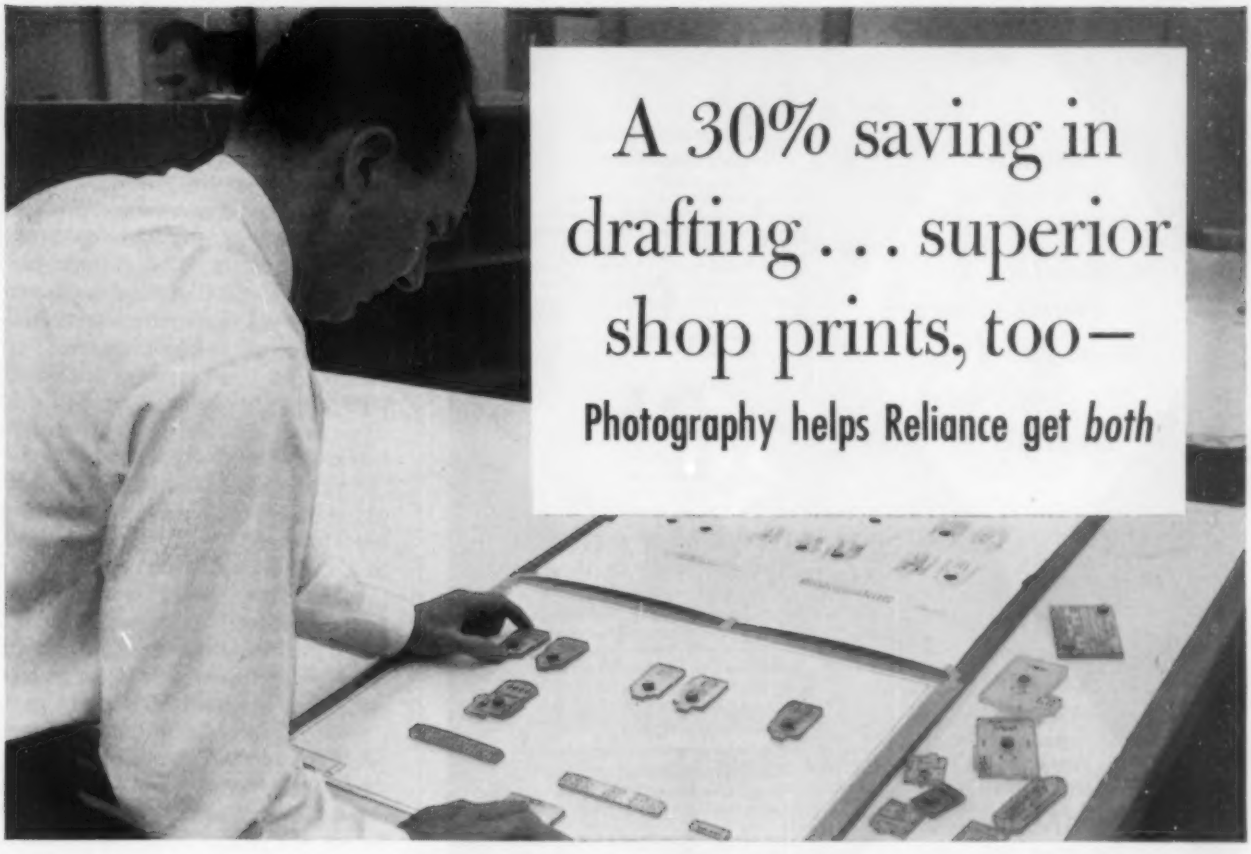
"Elastic Limit and Yield Behavior of Hardened Steels," Hugh Muir, Senior Lecturer in Metallurgy, University of Otago, Dunedin, New Zealand, B. L. Averbach, Associate Professor, and Morris Cohen, Professor of Physical Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

A method of high strain sensitivity is described for investigating the elastic limit and the initial yielding of heat treated steels. The elastic limit measured by this technique is shown to be equivalent to the stress above which there is increasing permanent deformation on repeated tensile loading to a given stress level. Discontinuous yielding is observed for steels tempered at the higher temperatures, but in each case, considerable plastic deformation precedes the yield point.

The elastic limit and other tensile data are presented for hardened steels containing 0.20, 0.41 and 0.82 per cent carbon as a function of the tempering temperature. The elastic limits are remarkably low in the as-hardened steels, being approximately 20,000 to 30,000 psi but increase to values of 100,000 to 130,000 psi on tempering in the range of 500 to 700 F (260 to 370 C), and then decrease to 13,000-60,000 psi on tempering at 1,300 F (705 C). Except when brittle fracture occurs, the yield, tensile and fracture strengths generally decrease with decreasing hardness as the tempering temperature is raised.

"Effect of Static Stress on Damping of Various Alloys," A. W. Cochardt, Research Lab., Westinghouse Electric Corp., Pittsburgh, Pa.

Wires of alloy type AISI 403 and Refractaloy 26, with weights sus-



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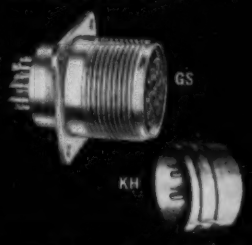

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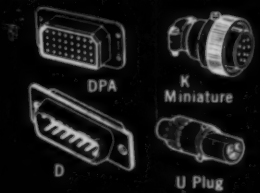

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pended on them, were twisted, and the decay of the free torsion vibration was measured. The static stress was varied between 910 and 51,000 psi, the vibrational torsion stress between 0 and 40,000 psi, and the temperature between 70 and 1,300 F (21 and 705 C). It was found that the damping of alloy type 403 is considerably affected by a superimposed static stress. For example, at a temperature of 750 F (400 C) its damping decreases with static stress by a factor of five at lower vibrational stresses. A different effect is observed in Refractaloy 26 whose damping always increases with static stress. The data are found to be in agreement with our present concept of the mechanism of damping, from which it follows that at lower vibrational stresses the damping generally decreases with stress in ferromagnetic materials while the opposite effect occurs in nonferromagnetic alloys. At larger vibrational stresses the damping behavior is governed by strain hardening and recovery, as a general rule.

"The Aluminum-Vanadium Alloy System" by O. N. Carlson, D. J. Kenney and H. A. Wilhelm, Institute for Atomic Research and Department of Chemistry, Iowa State College, Ames, Iowa.

An investigation of the aluminum-vanadium system was undertaken to determine the phase relationship existing and to propose a phase diagram. At the time the present investigation was initiated, the literature dealing with aluminum-vanadium alloys gave an incomplete and confusing picture of the system.

Materials. Massive aluminum having a reported purity of 99.9 per cent was used in the preparation of all samples whose properties are reported. The vanadium was prepared in the laboratory in sheet form by the reduction of vanadium pentoxide with calcium to obtain material of the required purity and ductility.

Alloy Preparation. Alloys were prepared by arc-melting vanadium sheet, together with the aluminum, under argon in conventional arc-melting equipment employing a tungsten electrode and water-cooled copper crucible.

Heat Treatment of Alloys. A large number of quenching experiments were conducted to obtain data on the phase boundaries of the system. These were carried out by annealing alloy

specimens at the temperature of interest, admitting helium into the system at that temperature and quenching the samples in water.

Summary. An investigation of the aluminum-vanadium system covering the complete composition range was conducted and the following salient features were established:

1. The solid solubility limit of vanadium in aluminum is 0.37 per cent V at 660 C (1,220 F) and lower temperatures.

2. An intermediate phase, α(Al-V), exists at approximately 14 per cent V and has been identified as $Al_{11}V$ (14.6 per cent V). It undergoes a peritectic transformation at 685 C (1,265 F).

3. Another peritectic phase β(Al-V) exists at approximately 24 percent V, undergoing a peritectic reaction at 735 C (1,355 F). This phase has been assigned the formula Al_4V (23.9 per cent V).

4. γ(Al-V), established as Al_3V prior to this investigation, was found to undergo a peritectic transformation at 1,360 C (2,480 F).

5. A fourth intermediate phase δ(Al-V) occurring at approximately 56 percent V has been shown to correspond to the formula Al_5V_7, (54.2 percent V). This compound undergoes a peritectic transformation at 1.670 C (3,040 F).

6. There is a region of extensive solid solubility of aluminum in vanadium, (V), extending to 70 percent V.

Influence of Automation On Machine-Tool Design

Abstracted from "Influence of 'Automation' on Machine-Tool Design," by F. R. Swanson, Director of Engrg., Sunstrand Machine Tool Co., Rockford, Ill.; presented at the Joint Session of the Machine Design and Production Engineering Divisions of the American Society of Mechanical Engineers, November 28-December 3, 1954, New York, N. Y.

In the early use of automatic work handling for machine tools, the manufacturer purchased a standard machine and designed a work-handling device to fit his own needs. This device was usually cumbersome and unreliable because the machine had not been designed with the device in mind. Improved single unit machines were designed integrating their own handling devices but they required an operator or helper to position the work

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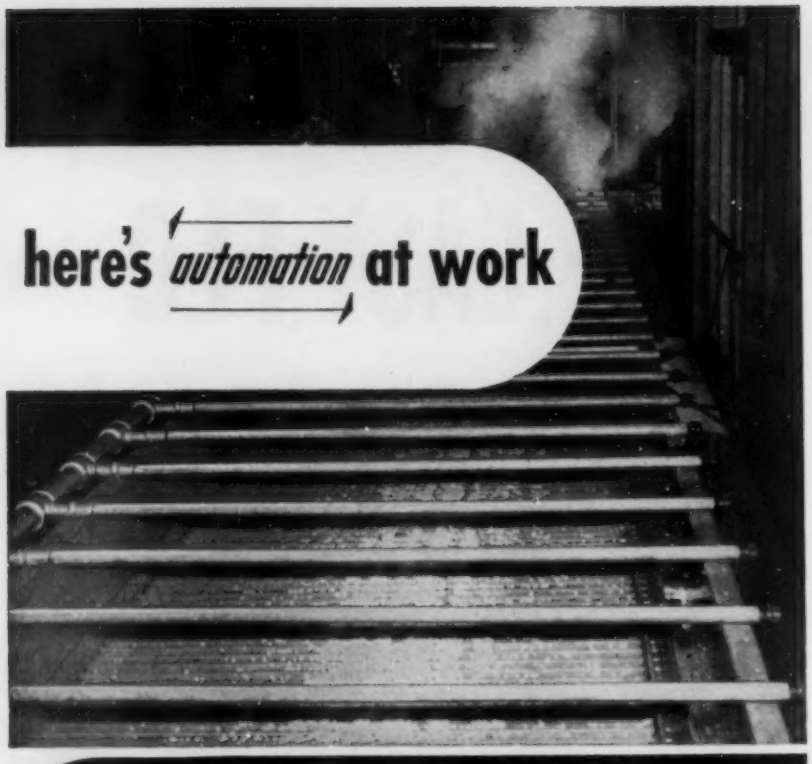

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on the receiving station or to remove the work and push it along a conveyor to the next machine in line. At present, machines are being designed to work as a fully automatic unit in an automatic factory. A machine tool may now be required to receive the work from the preceding machine, process the work through the necessary operations, free the work of chips, automatically gage and reject out-of-size work, stop machine, reset or insert sharpened tools, and deliver the work part to the following machine in the line. As a result, modern automatic machine design requires close cooperation of a group of engineers with imagination, engineering knowledge, and training in the various phases of machine-tool elements.

Spindle heads must be designed with adequate gear trains, bearings and spindles mounted in a housing that will transmit full horsepower continuously with a minimum of deflection and vibration in the cutting tool. Automatic lubrication must be provided to all points, and necessary seals must be included to prohibit dust and coolant from contaminating the lubricant. Also important is the easy access to all working parts for bearing inspection and adjustments. The type of feed selected will depend on the speed of operation. If this is six cycles or more per minute, hydraulics is usually the better choice. But whatever system is chosen, it must be designed for automatic control with facilities for initiation operation and interlocking with any other type of automation which may be used as a part of the entire operation.

The various engineering groups working together must consider the basic machine function, the various spindle heads, the feeds and traverse drives and the automatic control system, be it electrical or hydraulic, or a combination. In addition, safety for the machine, the operator, and the maintenance men must be integrated as a part of the design. Increased emphasis on design for rapid maintenance is required for automatic machines, since a single machine failure can result in a complete shutdown of a process or a production line until the faulty machine is put back into operation. Tools must be designed for rapid production in order to justify the increased cost of the automatic machine.

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MOORE PRODUCTS COMPANY of Philadelphia uses a Sanborn Model 60 two-channel Recording System to check the Dynamic Performance of their Valve Positioners, which are used on diaphragm top-work valves and power cylinders. The valve positioner acts as a relay, applying additional air pressure to the cylinder or top-work, overcoming effects of unbalance and friction, and compelling the valve stem to take the position dictated by the pneumatic controller or manually-operated air load. A feed-back linkage assures positioning of the valve stem within plus or minus 0.001".

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The above cases are but two of the many applications possible with Sanborn one-, two-, four-, six- and eight-channel Recording Systems. With a Sanborn you can register permanently and graphically virtually all electrical phenomena within a frequency range of zero to 100 cps. A choice of the number of channels, plus the ready interchangeability of various type preamplifiers (to meet individual recording problems) offers a wider versatility of use, greater overall economy, and increased operating efficiency.

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Thermal Conductivity of Metals and Alloys At Low Temperatures

ROBERT L. POWELL and WILLIAM A. BLANPIED, *National Bureau of Standards Circular* 556. 68 *pp. Order from the Government Printing Office, Washington* 25, *D. C.* $0.50.

Accurate data on the thermal conductivity of construction materials at low temperatures are essential in the design of cryogenic equipment. Such data on pure metals also have important applications in basic physics.

This Circular was prepared by the NBS-AEC Cryogenics Laboratory of the NBS Boulder Laboratories to satisfy the need for a complete and authoritative compilation of the useful but widely scattered data on thermal conductivity at low temperatures. It includes tables of measured values of thermal conductivity for metals and alloys from room temperature down to approximately 0 deg K. The more extensive and important data are plotted in 48 graphs. The data are essentially complete for literature reference from 1900 to early 1954. For comparison, several graphs and tables are given for some representative dielectric materials.

Schnitt-, Stanz- und Ziehwerkzeuge

Dr.-Ing. habil. GERHARD OEHLER, *Professor at the Technischen Hochschule Hannover,* 6¼ x 9¼ *in.,* 480 *pp. Published by the Springer-Verlag OHG., Reichpietsschufer* 20, *Berlin* W 35, *Germany.* DM 37.50, ($9.38 approx.)

Here is a book on the working of sheet metal that covers all phases of the subject with typical German thoroughness. Summarizing, the fourteen chapters of this second edition on "Blanking and Punching—Bending and Forming—Deep Drawing" cover in great detail the design and construction of blanking dies, punches, break-

ing dies, drawing dies, deep drawing dies used on double action presses, tools for stretch presses, drop hammers and all the types of specialized operations.

This is not a book that tells how "Johnny Jones did it." To the contrary, it is a highly noteworthy down-to-earth technical presentation replete with design equations, technical data, tables of properties, curves depicting relationships and similar basic engineering informations. It is obviously the work of an engineer who has mastered the art of sheet metal working in all its ramifications.

Although written in German, even engineers who are not at all familiar with the language can get much information and valuable ideas out of the charts, tables, and the detailed section and other views of dies and tool set-ups.

Industrial Design

HAROLD VAN DOREN, *Fellow, Society of Industrial Designers, Honorary Fellow, Royal Society of Arts. Second Edition, 7 x 10 in., 379 pp. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y. $6.50.*

One of America's foremost industrial designers gives a step-by-step introduction to the whole field of industrial design—from preliminary research and analysis, visualization and rendering—to model-making, consumer testing, and presentation to the client.

Thoroughly revised and supplemented with new illustrations, this Second Edition outlines the principles, techniques and procedures to follow in preparing mass-produced, three-dimensional products for a variety of markets. The book is both simple and non-technical, and offers a typical "how-to-do-it" approach to the whole problem. Several entirely new chapters have been added and cover pre-design research, independent analysis, merchandising, and testing consumer reaction to a proposed design.

Problems covered in the book fall into four main groups: those involving consumer goods; commercial or service equipment; capital or durable goods; and transportation equipment. Instead of sample solutions to a few

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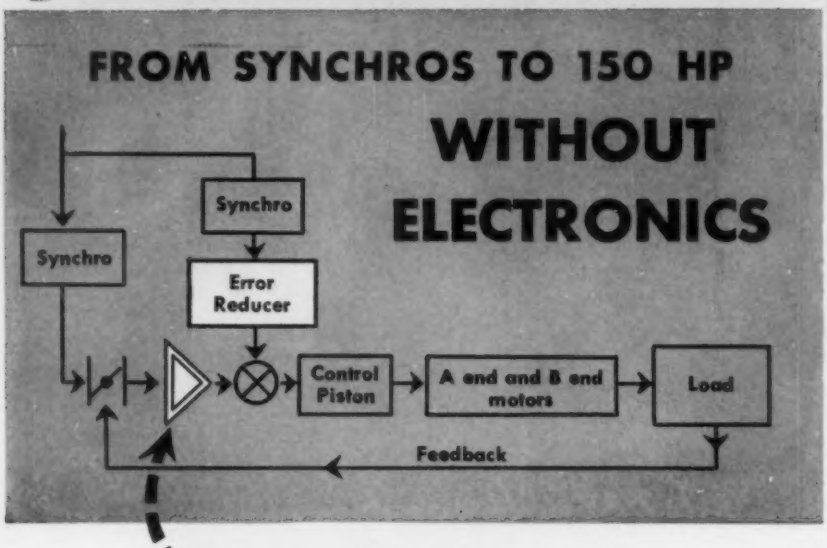

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This hydraulic amplifying system is typical of the unusual amplifying systems developed by Ford Instrument Company over the past forty years. Other examples are the electronic amplifier circuits in mission control computers for the Navy Bureau of Aeronautics, magnetic amplifier circuits for power drives, and transistor amplifiers for missile guidance systems.

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problems, the book presents a method of attack which can be applied to any problem. Clearly and simply, it describes the means of gathering information and organizing it into usable form, together with all the aesthetic and technical measures necessary to carry the project to a successful conclusion at reasonable cost.

Surface Coatings and Finishes

PHILIP L. GORDON, *Ph.D., American Waterproofing Corp., and* GEORGE J. DOLGIN, *Triad Paint and Chemical Corp.* 6 x 8½ *in., 299 pp. Published by the Chemical Publishing Co., Inc., 212 Fifth Ave., New York, N. Y.* $9.

Paint and varnish technology is no longer based on the exclusive use of natural resins and vegetable oils cooked in small, open kettles. Present-day vehicles may be made up of the synthetic resins, such as phenolics, glycerol esters of rosin and their modifications, in combination with quick-drying and water-resistant oils.

This book reviews the standard methods of preparing and using the orthodox varnish vehicles and describes the structure, use and practical value of the plastic materials now available for surface coatings. Numerous tables, graphs and illustrations are used to show the apparatus and techniques required to meet physical and performance requirements of surface coatings and finishes.

The chapter on testing methods should prove particularly useful to research students as well as manufacturers and engineers who want to set up specifications for a coated product.

Materials of Construction

M. W. WITHEY, *Emeritus Dean, College of Engineering, and* G. W. WASHA, *Professor of Mechanics, University of Wisconsin.* 6 x 9 *in., 969 pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.* $9.

This book contains considerable data on the sources, manufacture and fabrication of the principal materials of construction. The data includes the more important physical properties and the causes of defects and variations. Apparatus and procedures for

destructive and nondestructive testing are fully discussed.

Three chapters are devoted to wood and the uses of timber as a construction material. Other materials such as stone, clay, Portland cement and concrete also receive the same full discussion. The section on metals covers almost half of the book and takes the reader from the occurrence and reduction of metallic ores, through the manufacture of iron and steel, and includes data on the nonferrous metals.

Since the aim of the authors is to present a book that serves both as a text and a reference book, this reviewer feels that future editions should contain mention of the growing use of plastics in construction. A chapter on paints and other surface finishes should be added to complete the roster of construction materials.

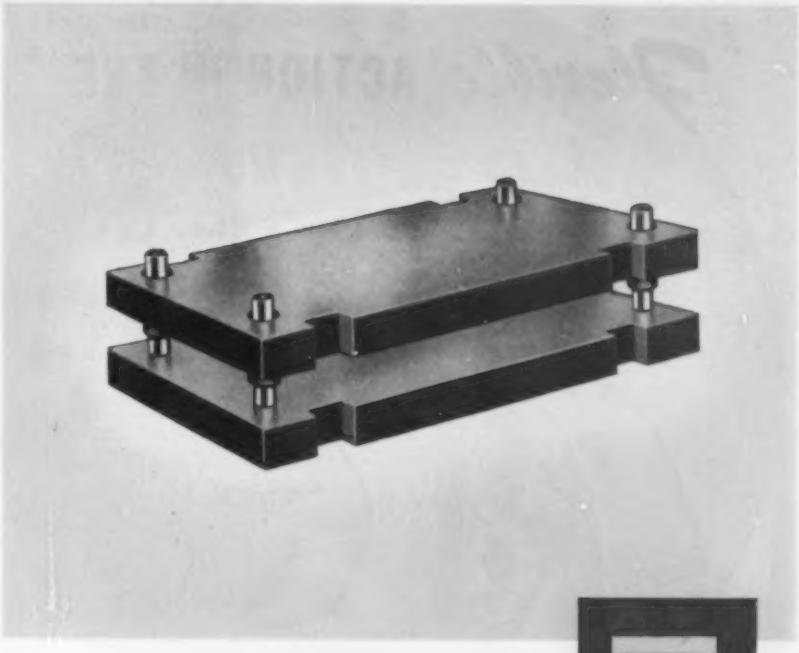
Cook Technical Review

Compiled by the Cook Research Laboratories. Flexible cover, 8½ x 11 in., 113 pp. Published by Cook Research Laboratories, a division of Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill. $1.00 in U.S. and Canada; $1.25 in other countries.

This first volume is a compilation of articles and papers covering much original work by D. C. McDonald, Assistant Director of Cook Research Labs., and other staff members. The book presents new concepts in servomechanism design and analysis, and also describes the application of nonlinear analysis and synthesis techniques to linear servos.

The early part of the review contains discussions of the design of operational amplifiers in analog computers for servomechanism problems. A description and analysis of electromechanical lead networks for a-c servomechanisms having superior characteristics to conventional a-c networks, and also a simple method of designing stabilization circuits for improving servo response is included.

Fundamental limitations in recent and new techniques of linear servo analysis are discussed. Improvements in linear system performance by the addition of nonlinear elements without improvements in existing controllers and servo motors, are described. Phase plane and space analysis is ap-



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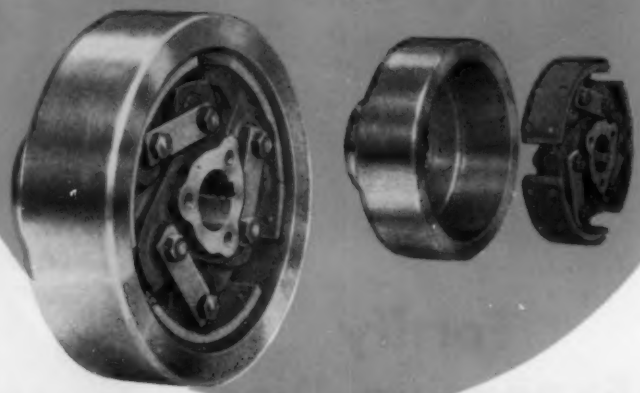

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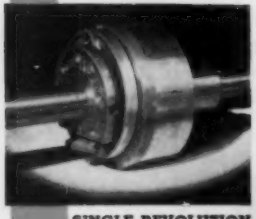

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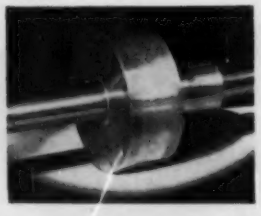

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plied to nonlinear servo problems to give an analytical interpretation of the effect of nonlinear elements, and to assist in the design of nonlinear servos.

A paper is included which describes the results of experimental tests on servomechanisms employing the principles of multiple mode operation. This type system operates at maximum torque and reversible polarity for all values of error greater than some predetermined allowable maximum. For all values of these variables less than this maximum, the servo returns to conventional linear servo operation. This type of system shows an improvement in time-response, since the rate of reducing error is always the greatest theoretically possible in the maximum torque mode. It is practice to construct a system giving improvements in the time response to step inputs by factors of from 3 to 5, while also retaining a response characteristic similar to a critcally-damped linear response, that is, no overshoots. The frequency response of the dual-mode system is an improvement over the linear. Furthermore, for one specific system, a considerable saving in size and weight has been effected through multiple-mode control.

Servomechanism Practice

WILLIAM R. AHRENDT, *President, the Ahrendt Instrument Co., Lecturer, University of Maryland.* 6 x 9¼ *in.*, 349 *pp. Published by the McGraw-Hill Book Co., Inc.*, 330 *West* 42*nd St., New York* 36, *N. Y.* $7.

The purpose of this book is to explain in detail the practical aspects of servomechanisms, to describe the many ways in which the essential function of servomechanisms components can be accomplished, to discuss the problems associated with the operation of servos and their components, and to outline practical design and manufacturing techniques to obtain optimum performance. This book also covers description and detailed design data on all the important servomechanisms components.

Other books have dealt almost exclusively with the theory of the subject. This book is unique in that it deals with circuitry, electrical and mechanical components and the recent advances in their performance

and utilization, plus practical problems encountered in servo design and manufacture. Actual design procedure used in servomechanisms is described, and the manufacture, a subject ultimately related to performance, is treated. Particularly stressed are the departures from idealization of the various components, and more important, what can be done about them to achieve the limit of their performance.

Problems and questions accompany each chapter and are so arranged that a thorough review, or a classroom discussion, provides a review of material in the chapter itself. The material is also written so as to suggest a vast number of laboratory experiments.

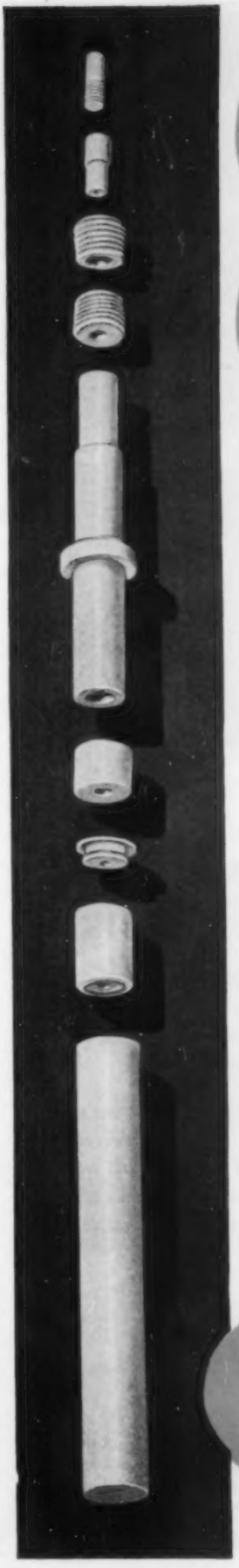
Thermodynamics

FRANKLIN P. DURHAM, *University of Colorado.* 6 x 8½ *in.*, 312 pp. *Published by Prentice-Hall, Inc., 70 Fifth Ave., New York, N. Y.* $7.35.

Although many available textbooks on thermodynamics are considered to be excellent by an instructor familiar with the subject, these same books are often inadequate for the student who is unfamiliar with the subject. With this in mind the author has written this book to provide a text specifically for students of the subject.

The material in this book provides a fundamental background in the field of thermodynamics, that science dealing with the study of energy, energy transfer, and the media employed. The prime emphasis in this book is on work, heat, and the flow of gases and vapors, and is basic to the further study of such fields as internal combustion engines, gas turbines, steam power plants, jet engines, aerodynamics, fluid mechanics, refrigeration, and heat transfer.

This book develops the basic theory of thermodynamics in terms of a minimum number of simple equations. The first six chapters develop basic theory such as types of energy, properties of thermodynamic media, the first and second law of thermodynamics, and the ideal gas; and chapter seven summarizes these laws on the basis of two groups: those that apply to any thermodynamic medium, and those that apply to the ideal gas. Chapters seven through 12 discuss specific applications of theory includ-



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ing engine cycles, vapor power cycles, refrigeration, nozzles and jet propulsion and mixtures. Chapters on gas dynamics and heat transfer are also included for use in curricula where no special courses in these subjects are taught.

The text presents, in simple form, the requirements for and necessity of reversible processes in the analysis of ideal thermodynamic processes. The concept of entropy is introduced early in the text, and is integrated throughout, along with the treatment of irreversible processes. The concept of stagnant conditions in steady flow processes and importance of their use is introduced in this book. A prime feature of the book is use of a set of symbols incorporating a system for the distinction between entire and specific quantities, molar quantities, and quantity rates—with no double meanings or ambiguities.

A considerable amount of valuable reference material is included in eight appendix tables and five appendix charts which are handy for reference.

ASTM Standards on Copper and Copper Alloys

Sponsored by ASTM Committee B-5 on Copper and Copper Alloys, Cast and Wrought. 6 x 9 *in., paper-bound,* 600 *pp. Published by the American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $5.

This book brings together in compact, readily usable form all of the ASTM Standards pertaining to copper and copper alloys, which were developed by ASTM Committee B-5, and related standards from other committees of the ASTM. This edition presents in their latest form 123 ASTM standards, including 108 specifications; 10 test methods; 2 classifications: one of coppers, the other of cast copper-base alloys; 2 recommended practices: one for tension test specimens for copper-base alloys for sand castings, and one for designating significant places in specified limiting values; and 1 hardness conversion table for cartridge brass. In this special compilation, 50 of the specifications included in the earlier edition have been revised and 8 of the standards are new.

Standards cover: specifications for

electrical conductors; plate, sheet, rolled bar and strip; rod, bar and shapes; non-ferrous metals; wire; pipe and tube; ingot; sand and die castings; filler metal; and methods of test for copper and copper-alloys.

New material includes specifications and test methods for: round chromium-copper wire for electronic devices; seamless copper tube for refrigeration field service; copper and copper-alloy die forgings (hot-pressed); soft or annealed coated copper conductors for use in hookup wire for electronic equipment; copper-zinc-manganese alloy (manganese brass) sheet and strip; nickel-tin bronze castings; determination of cross-sectional area of stranded conductors; and stiffness of bare soft square and rectangular copper wire for magnet wire fabrication. An extensive index is included for ready reference.

Control-System Dynamics

WALTER R. EVANS, *Systems Group Leader, Electromechanical Engineering Department, North American Aviation, Inc.* 6¼ x 9¼ *in., 277 pp. Published by the McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y.* $7.

This new text demonstrates classical and new techniques for determining the response of linear control systems including meaning and use of transfer functions in frequency-response method, transient response from frequency response, and the Root Locus Method invented and developed by the author. The root locus, a tool used to factor an algebraic polynomial, is useful in analyzing the pertinent differential equations in feedback control systems.

This book is both a textbook for college courses and a reference book for practicing engineers who want to learn this field and is written so that the reader may begin with any of the first seven chapters depending upon his previous knowledge. The beginning chapters state basic dynamics problems involved in control systems and describe several of the transducers, motors and other components used in control systems. An explanation of the meaning and use of the transfer functions is followed by a basic explanation of the Frequency-

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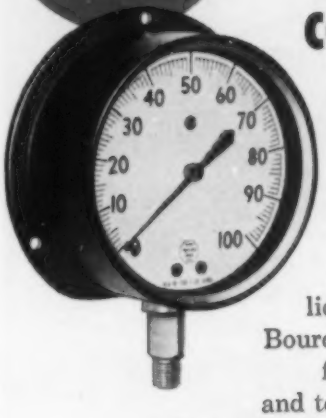

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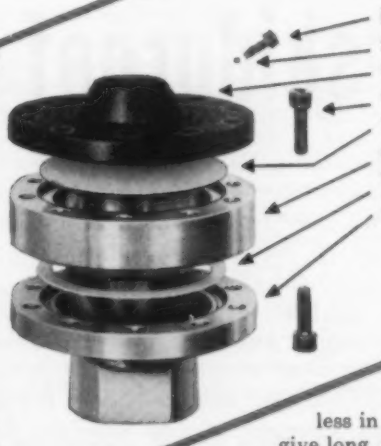

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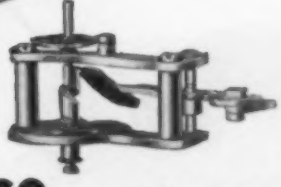

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Response Method of system analysis. The meaning of transfer functions developed from a study of the classical solution of simple differential equations rather than by use of the Laplace transform.

The Root Locus Method, as developed by the author, is a graphical method for finding the roots of the characteristic equation of the form $F(s) + 1 = 0$, in which $F(s)$ is in factored form. The Root Locus Method and the Frequency-Response Method both provide techniques for finding the response of a closed-looped system from its open-looped response. The first method starts and ends with transfer functions in analytic form. The second method starts and ends with frequency-response data. The advantage of knowing the transfer functions is that transfer response can be calculated directly. Analysis of both single-loop and multiple-loop systems are covered in detail.

The simplest problem presented is a change in speed of a motor to a sudden applied voltage, while the most complex is the interaction of the roll and yaw motions of an airplane. Each solution establishes a concept that permits a simpler technique to be applied to the next more complicated problem. Throughout, the author emphasizes physical understanding of the problems as contrasted with memorizing a routine for solving particular ones. The physical picture of a solution is always developed first with the mathematics introduced later, as needed.

Seven useful appendices are included which contain, among other subjects, an explanation of the Laplace transform, aids in sketching Root Locus plots, and Routh's Criterion.

Monomeric Acrylic Esters

EDWARD H. RIDDLE, *Special Products Dept., Rohm & Haas Co.* 6 x 9 *in.*, 221 *pp. Published by the Reinhold Publishing Corp.*, 430 *Park Ave., New York* 22, *N. Y.* $5.

Written by a group of research chemists and chemical engineers at Rohm & Haas Company, this book provides considerable information on commercially available acrylate and methacrylate esters.

The book begins with a brief his-

tory of acrylic monomers and polymers, including the processes formerly and now used in the preparation of monomeric acrylic esters. The physical properties of both the technical grades and purified materials are then presented, together with methods of removing inhibitors, explosive limits, toxicity and facilities for unloading and storage of monomers. Subsequent chapters describe methods used to polymerize monomeric acrylic esters, their copolymerization with other commerically available monomers, the uses of acrylic esters and intermediates in chemical reactions other than polymerization, and methods of determining the purity of monomers.

Recent advances are covered in all chapters, and particular attention is given to the latest theories of polymerization and copolymerization mechanisms involving monomeric acrylic esters.

The book is highly technical and obviously was written for the industrial chemist or chemical engineer who is working with these monomers.

Strength of Materials

JOSEPH MARIN, *Professor and Head, Dept. of Engineering Mechanics; and* JOHN A. SAUER, *Professor and Head, Dept. of Physics, the Pennsylvania State University. Second Edition, 6 x 9½ in., 518 pp. Published by The Macmillan Company, 60 Fifth Ave., New York 11, N. Y. $6.75.*

The purpose of this book is to provide a clear account of the science of mechanics of materials and its application to simple problems of design. The logical treatment of topics starting from simple stress systems, such as members subjected to simple tension, shear, or bending, and leading gradually to more complex systems, such as statically indeterminate structures and combined stresses, differs only in minor respects from that of the First Edition. This Second Edition retains one of the main features of its predecessor: that of giving a brief treatment of the mechanical properties of materials with each type of stress considered. Instructors who do not wish to include mechanical properties in a first course can omit the chapters and sections dealing with mechanical properties without de-

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stroying the continuity of the remaining material. Another feature of the book is correlation of stress analysis, mechanical properties and design. This correlation is intended to prepare the student more adequately for the study of machine, structural aircraft design.

To include recent developments and provide greater clarity, the book has been almost entirely rewritten, and a considerable number of topics added. New material includes two new chapters and a number of additional sections, such as those on stress concentration, beam columns, and vibrations of beams. The first new chapter includes a discussion of creep and temperature properties of materials, and has been added because of the interest in this subject matter that has arisen from industrial and military technological developments of recent years. Such developments include jet engines, high-speed aircraft, and lightweight structures.

The second new chapter discusses experimental methods of stress analysis. Many new developments have occurred recently in this field, and a number of convenient and relatively simple methods of stress analysis are now available. These methods are extremely useful in applications where theoretical solutions are not possible or where such solutions can be obtained only by making drastic assumptions. While limitations of space do not permit a complete treatment of these methods, brief consideration of those regarded as most important—the strain gage, the strain rosette, and the photoelastic and stress-coat techniques—is considered essential and is, accordingly, included.

Where advances have been made in theory and/or in practice, related subjects have been brought up-to-date. In particular, changes were made in Chapter 9 on theories of failure and in Chapter 12 on fatigue and impact properties.

Three important changes have been made with regard to problems. First, many new problems have been added and old problems revised wherever necessary. Second, problems have been transferred from the ends of chapters to positions succeeding the relevant sections. Third, problems of design have been directly incorporated with those on stress analysis. These

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15.0 seconds at 1.5 HP
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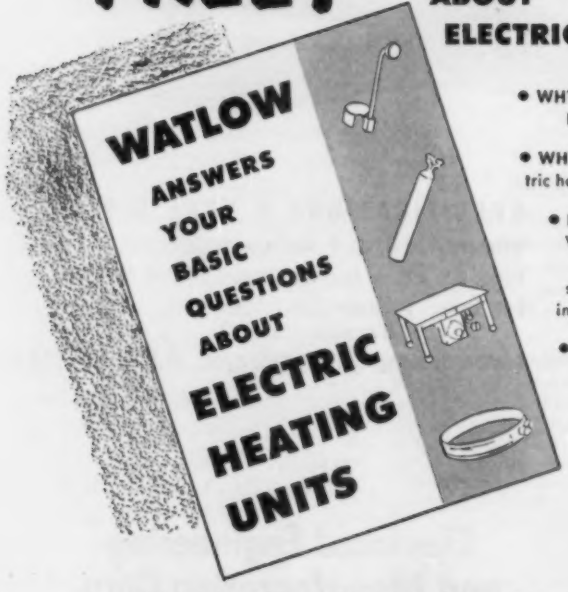

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changes should facilitate coordination between development of theory and its application, whether to stress analysis or to design, and should facilitate use of the problems both by the instructor and the student.

The book is organized in a way that permits its use in either a short or long course. The first six chapters, together with selected topics from other chapters, supply ample material for a one-semester course; for courses of longer duration, many of the more advanced topics of the later chapters can be included. These chapters have been so written that omission of any one will not destroy the continuity of the remaining subject matter.

Fundamentals of Electromagnetic Waves

PAUL C. SHEDD, *Professor of Electrical Engineering, Newark College of Engineering.* 6 x 8½ *in.*, 191 *pp. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York, N. Y.* $5.65.

This is a new book in the Prentice-Hall Electrical Engineering series, in which the material presented is designed to familiarize students of electrical engineering and physics with the fundamental principles of electromagnetic fields, and to lay a basis for a study of electromagnetic waves. All knowledge of mathematics beyond this point is developed as needed, as an integral part of the book.

This study of electromagnetic field theory is based on the logical, rather than historical approach, and makes use of the following four postulates: conservation, continuity, superposition, and special relativity. The work is restricted so that only large aggregates of elementary particules are considered, and quantum mechanics and generalized relatively and unified field theories are not taken into account. With these restrictions, the four required fundamental concepts selected are: space, time, mass, and electricity. All other physical concepts employed are defined in terms of these four, or in terms of concepts so defined, by means of mathematical equations.

This book consists of 32 short, concise chapters, developed in a logical manner beginning with a review of vector algebra and differentiation and integration of vectors with respect to

scalars, and vice versa. Fundamental electrical laws of charge and flux densities are stated on the basis of Coulomb's law and Gauss' law. An explanation of polarized atoms and the fields in polarized dielectrics is followed by an analysis of the properties of dielectrics.

Chapters one to eight explain electrical phenomena in terms of electric fields and flux densities; followed by chapter nine, introducing the concept of an electric scalar potential, which is of aid in rapid solution of many important problems. Chapters 10 through 12 derive the divergence theorem and its companion, Stoke's theorem, followed by an introduction to the use of curvilinear coordinates.

The remaining portion of the book is a logically developed treatment of electric charges and fields, electric current and the changing flux theorem. Of the final four chapters three are devoted to waveguide theory, while the last is on antennas. A short appendix contains the Lorentz transformation for space and time, and the addition of speeds according to the theory of relativity.

Air and Oil Cylinders In Industrial Applications

ELMER F. HEISER. 7¾ x 10½ *in.*, 122 *pp. Published by the Industrial Publishing Group, The Industrial Publishing Co., 1240 Ontario St., Cleveland 13, Ohio.* $5.

This book is devoted exclusively to fluid power cylinders. It attempts to answer some of the most frequently asked questions and problems encountered in working on cylinder design, selection and application, and contains twenty-one chapters well illustrated with sketches by the author. One chapter, "Cushion Limitations and Variations," is a practical treatment of cushions, and describes the subject in detail. There are other chapters devoted to Ordering Information, Operating Speed, Shock, Mounting Clearances, and Air Power-Oil Control. A final chapter has twelve short case histories of applications.

A ten-page Appendix contains commonly used charts and tables, including J. I. C. Hydraulic and Pneumatic component symbols.

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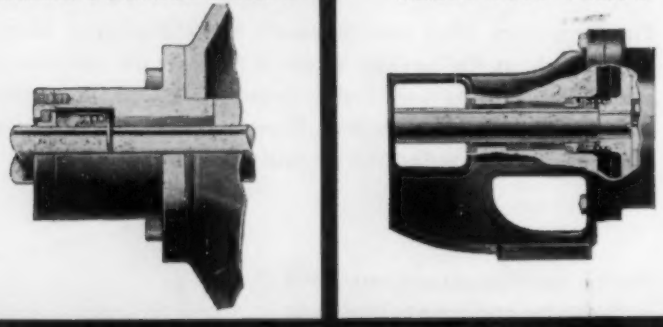

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Help Wanted on Worm Gear Equation

To the Editor:

In the January and February, 1934 issues of *Product Engineering* is a two-part article "Practical Data and Formulas for the Design of Worm Gears" by C. H. Grill. I refer to this article occasionally and would like to know if Eq (3) on page 64 of the February issue is correct as presented. Perhaps some of your readers who design worm and worm gears could help me; if so I would like to hear from them.

This equation as published reads:

$$L_a = TL_s\left(\frac{600}{600 + V_s} + \frac{MF}{SF}\right)$$

in which

L_a = total allowable dynamic load on worm gear tooth, lb
L_s = allowable static load on gear tooth, psi of projected tooth area
T = projected tooth area of contact, sq in.
V_s = worm pitch line velocity, ft per min
MF = material factor
SF = service factor

I am wondering whether the plus sign in this equation is proper.

Material factors run all the way from 3 to 1, and service factors from 0.333 for cast iron, to 3 for manganese bronze, and in the specific case which I have in mind, it seeme dto allow considerably high tooth loads. In taking the extreme allowances of a worm at 600 ft per min pitchline velocity, which gives for the Barth factor value of 0.5, and then taking, at the one end, the manganese bronze wheel with light duty service factor equation 3/1, and then, at the other extreme, the material factor of cast iron at 0.333 over the service factor of 3, gives a value of 0.1, approximately, and the value of the Barth factor plus the material/service value in the parentheses can vary from 30.5 on the heavy side to 0.06 on the low or high duty side,

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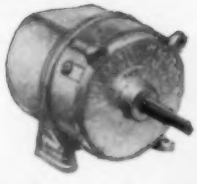

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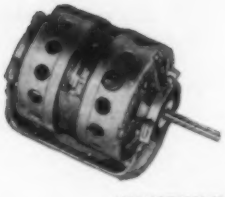

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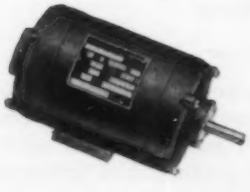

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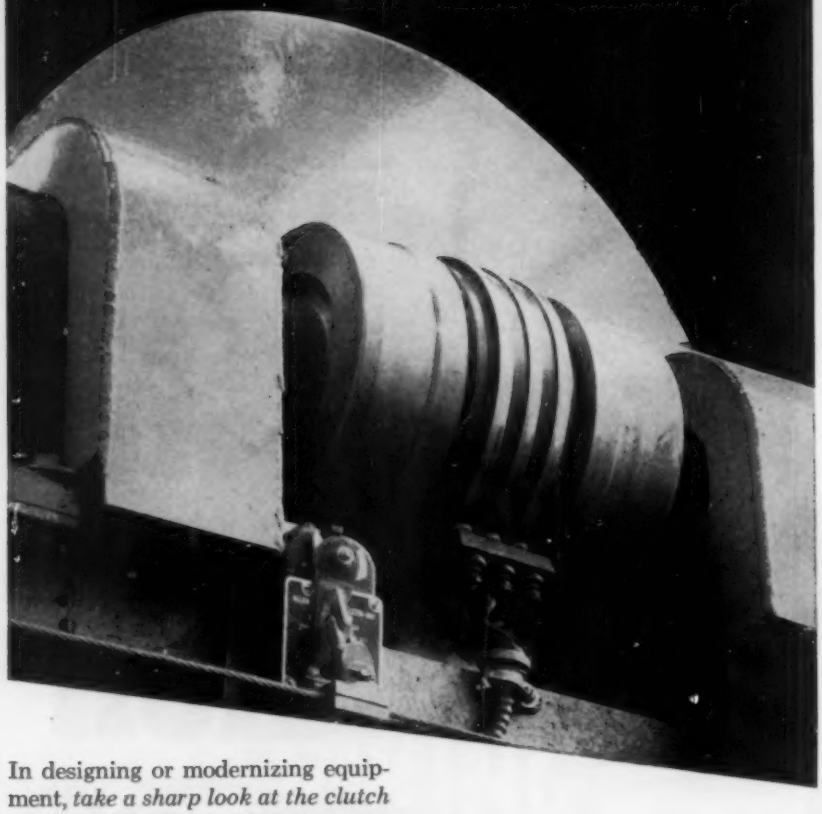

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or a variation of 51 to 1 in the load-carrying ability of the wheel sets. And merely studying this, I should like to question or to check the equation within the parentheses.

Inasmuch as I regard this particular article highly, is there anything with which you could help me to check this formula, and to give me any leads on later data in this direction?

It also seems that the limiting worm pitch line velocity of 200 ft per min is low, as we have a drive which has operated at from 370 to 750 ft per min, for years, without wear.

—Charles F. Van Hook
Watson Machine Co.

Ed—As we have no address for author Grill, we would welcome comments on the part of our readers.

Getting the Record Straight

To the Editor:

On page 154 of your July 1954 issue you incorrectly credit Century Lighting, Inc. with the design of the Negator-actuated counterbalancing device.

Reference to the Hunter Spring Company's publication *The Hunter Press*, dated October 1949, will show that this device was actually designed by Display Lighting Inc. a long time ago; and redesigned to employ Negators immediately following Hunter Spring's first public announcement of the Negator.

At the time, the writer was Vice President of Display Lighting, in charge of design and development. In 1952 Century Lighting, Inc. first placed an exact duplicate of Display Lighting's "Skybook" on the market.

—Edison Price
Edison Price, Inc.
Philadelphia, Pa.

Four Points for Block Letters

To the Editor:

My comments are based on more than 40 years of actual drafting board work which includes current application in the preparation of engineering as well as patent office drawings. In my opinion, *simplicity means clarity*, and block letters on mechanical draw-

PROOF

THAT YOU GET MORE MOTOR

FIELD-TESTED, FIELD-PROVEN FOR OVER 70 YEARS

Acceptance of ACEC motors is the result of *quality* engineered into every component . . . rigidly *controlled* at every step of manufacture . . . and *proven* by years of rugged field use. Amazingly, they cost less and they continue to cost less in maintenance, down-time and replacement. ACEC motors are a guarantee of long, trouble-free service.

Compare the prices of ACEC motors and those you've been buying. See how the most modern manufacturing methods give more motor for less money.

1. FRAME is rigid cast-iron normalized stress-relieved against distortion, maintains perfect alignment of bearings, shaft and end bells, assuring long bearing life and quiet operation.

2. PRECISION STATOR CONSTRUCTION of non-aging, high efficiency silicon steel, with exceptional magnetic and thermal properties, secured in perfect alignment. Stator coil windings are of high-dielectric FORMACEC insulation. First plastic coat is oven-dried. Two impregnating coats are separately baked-on, plus one additional protective coating of glyptal, to provide maximum protection against oil, moisture and chemicals — under all operating conditions.

3. SKEWED ROTORS — dynamically balanced rotor (in two planes) exceeds NEMA standards, reduces noise, vibration, and wear, guarantees maximum electrical and mechanical efficiency through the complete speed and load range.

4. TURBINE-TYPE FAN assures lowest operating temperatures.

5. SHAFT forged of high tensile steel, precision ground.

ACEC motors are available for immediate delivery from stocks warehoused in your area. For more information, call your ACEC field engineer or one of the 285 Authorized ACEC Distributors in the U.S. and Canada.

Write for our new bulletin on any of the following motors: O.D.P — T.E.F.C. — V.H.S. — Explosion-Proof — Gear — Wound Rotor — Synchronous — Variable Speed.

NEMA standards, plus!

ACEC ELECTRIC CORPORATION

40 E. 49th St., New York 17, N. Y. *OFFICES IN PRINCIPAL CITIES*

55-3

SOMETHING NEW
YOU CANNOT AFFORD TO MISS
INEXPENSIVE

- 12 SIZES
- VERSATILE
- MANY FEATURES YOU HAVE NEVER BEFORE FOUND IN A BLOWER
- BEAUTIFULLY FINISHED

MODEL "U" UTILITY blowers are specially designed for electronic, instrument and light industrial applications. They are compact and move large volumes of air in relation to their size and weight. Handy mounting arrangements as well as integral ducting connectors are a designer's delight. The blowers are driven by the new General Electric, nylon-insulated, all-angle, sleeve bearing, NEMA, motors and are . . .

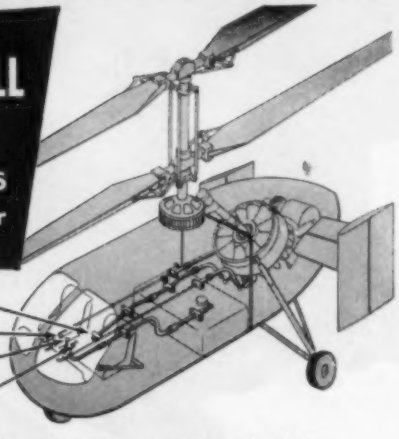
1-PHASE
115-230 VOLT
CAP. START

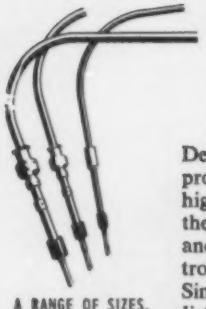
NORMAL DELIVERY ONE WEEK

ROTRON

ROTRON MFG. CO.
Schoonmaker Lane Woodstock, N. Y.

SIMMONDS PUSH-PULL CONTROLS
SOLVE 6 KNOTTY PROBLEMS
In Gyrodyne Model 2C 'Copter


COLLECTIVE PITCH CONTROL INCORPORATING THROTTLE IN TWIST GRIP
CARBURETOR AIR HEAT CONTROL
MIXTURE CONTROL
FUEL VALVE CONTROL



A RANGE OF SIZES, VARIETY OF FITTINGS

Designers of this advanced coaxial rotor helicopter had these problems in laying out the engine controls of this ship: constant high amplitude, low frequency vibration, confined space aft of the firewall, unusual position of the carburetor beneath engine and a requirement for minimum backlash and easy working controls under little leverage. All these requirements were met by Simmonds Precision Push-Pull Control Systems—one of a long list of successful applications of Simmonds controls on advanced helicopters and other military and commercial aircraft.

Write for detailed information on Simmonds Precision Push-Pull Controls.

Simmonds AEROCESSORIES, INC.
General Offices: TARRYTOWN, N. Y.

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ings serve best for the following reasons:

(1) They are more easily formed by the beginner as well as the experienced draftsman.

(2) They require but two guide lines and do not extend above or below these lines.

(3) They "fit" with mechanical drawings, whereas lower case letters seem to adapt themselves better for architectural drawings where an artistic touch is advantageous.

(4) When a draftsman makes alterations on an existing drawing, it is easier to follow the block letters in reprinting. This reduces the messy appearance resulting from trying to duplicate a free-hand styling of most lower case lettering.

—William A. Winters, Sr.
Glendale, Calif.

Ed—Comments such as these and suggestions in the fertile field of simplified drafting practices are earnestly solicited.

There's Plenty In the Spelling of a Name

To the Editor:

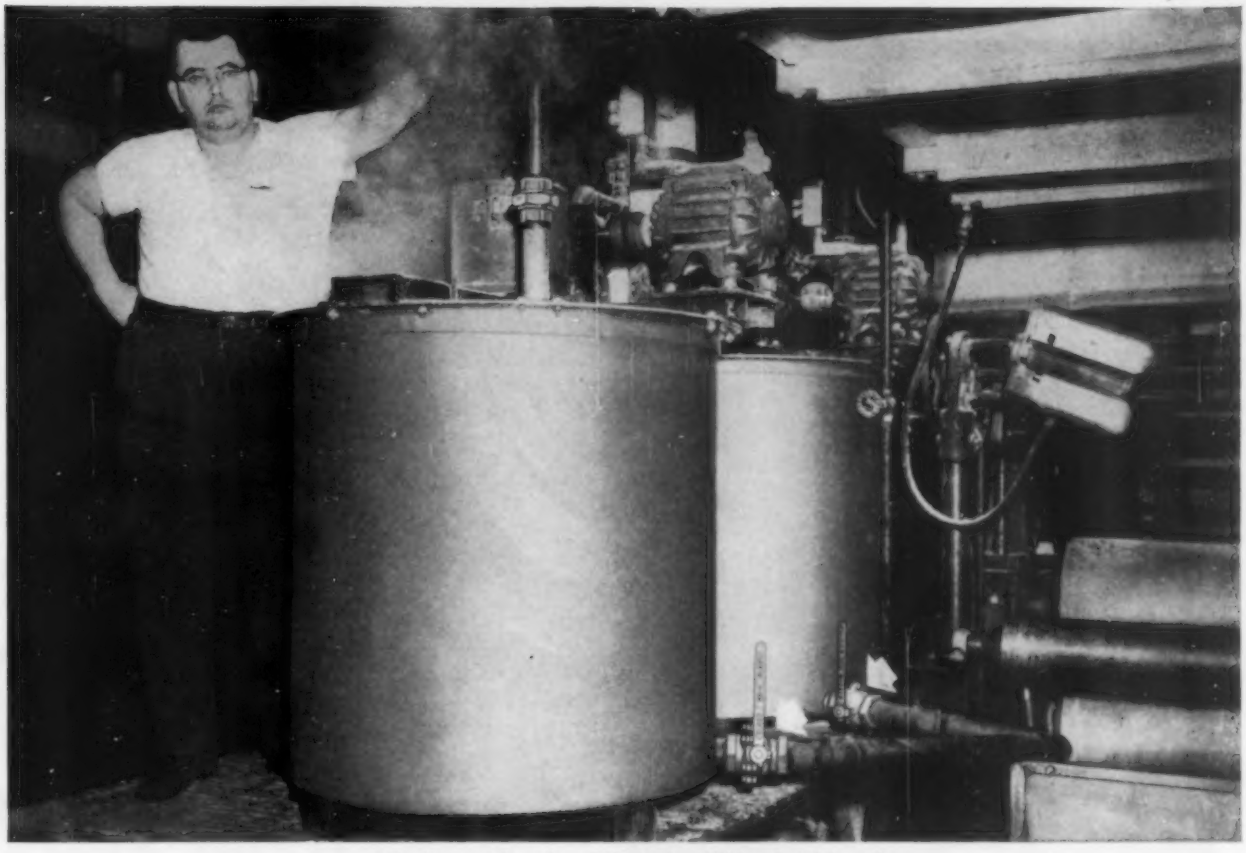
My name has been mis-spelled in my article "Factors of Safety in Tolerance Specifications" that begins on page F6 of the 1955 Annual Handbook of Product Design; also, the name of Willys-Overland Motors, Inc., has been changed to Willys Motors, Inc. I would appreciate if future references could be corrected.

—Nelson G. Meagley, *Manager Statistical Quality Control*

Ed—We regret the error and are much embarrassed that an author's name was mis-spelled in spite of all our editorial checking.

Correction

On page 224 of the November, 1954, *Product Engineering*, the engagement between male and female members of the tri-lobe coupling made by Kerns Mfg. Corp., 45-18 Court Square, Long Island City 1, N. Y., was said to be "held to 0.0020 in. max side clearance." This was incorrect and should have read 0.0002-in. side clearance.



Boiling Hot Starch flows through these valves. Old-type lasted 6 months. Rockwood ball valves have been in 4 years and are still going strong.

Want valves you don't have to replace?

Perhaps what you're handling isn't as tough as boiling hot starch. But whether it's worse or better you don't want to keep changing valves.

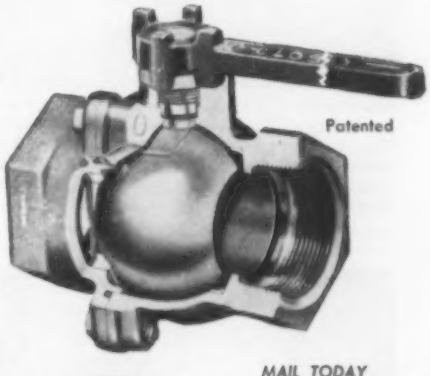
The Harodite Finishing Company of North Dighton, Mass., says Rockwood ball valves have lasted longer in the service than any they have ever used. Present Rockwood valves are 4 years old — leakproof, fast-acting, reliable. Other types used lasted from 6 months to a year. The master mechanic says he'd buy them on performance alone — with the longer life as a bonus.

If you want full round flow, quick action and long life in valves — what you want is Rockwood.

Four features you need . . .

1. **Full round flow** — no turbulence in fluid stream.
2. **Leakproof** — after continued use.
3. **Quick opening and closing** — with quarter-turns under full pressure.
4. **Longer life** — longer periods between replacement and no maintenance.

Tested and listed by Underwriters Laboratories, Inc. Comes in all pipe sizes.



ROCKWOOD BALL VALVES

FULL, ROUND FLOW

MAIL TODAY

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
601 Harlow Street
Worcester 5, Mass.

Send me illustrated folder V-4 on Rockwood Full-Flow Ball Valves.

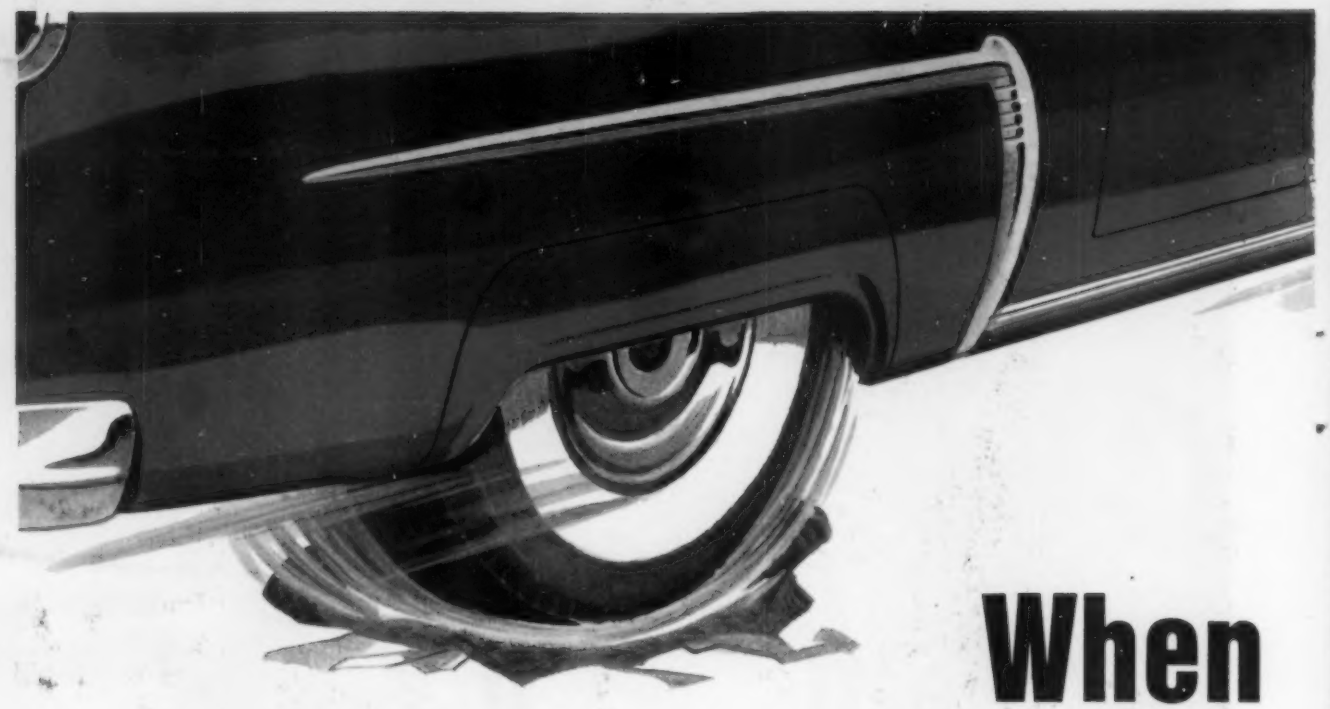
Name _____

Title _____

Company _____

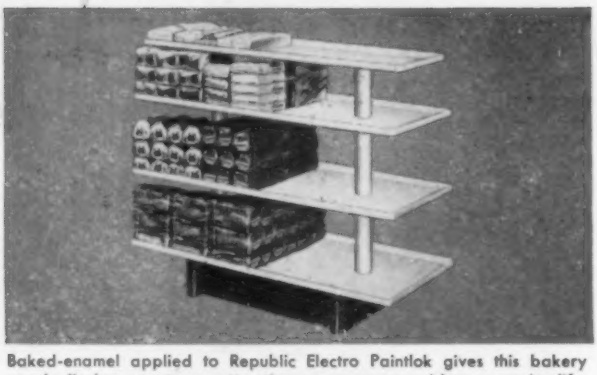
City _____

Zone _____ State _____



When

SPECIFY REPUBLIC



Baked-enamel applied to Republic Electro Paintlok gives this bakery goods display a customer-attracting appearance and longer service life. These zinc-plated steel sheets are chemically treated to take paints, lacquers, synthetic enamels—and hold them for years. If you paint on steel, consider Electro Paintlok for making your fabricated steel products more attractive, more serviceable, at less cost.

Revenue increased 15% to 40% when these rental lockers were made from Republic ENDURO Stainless Steel. Yet, costs were only 9% more than for carbon steel, painted. ENDURO's bright, attractive finish generates "sell". No other material offers the designer so many advantages. Republic makes ENDURO in all commercial forms. Republic metallurgists will help you apply its bonus benefits to your product or process.

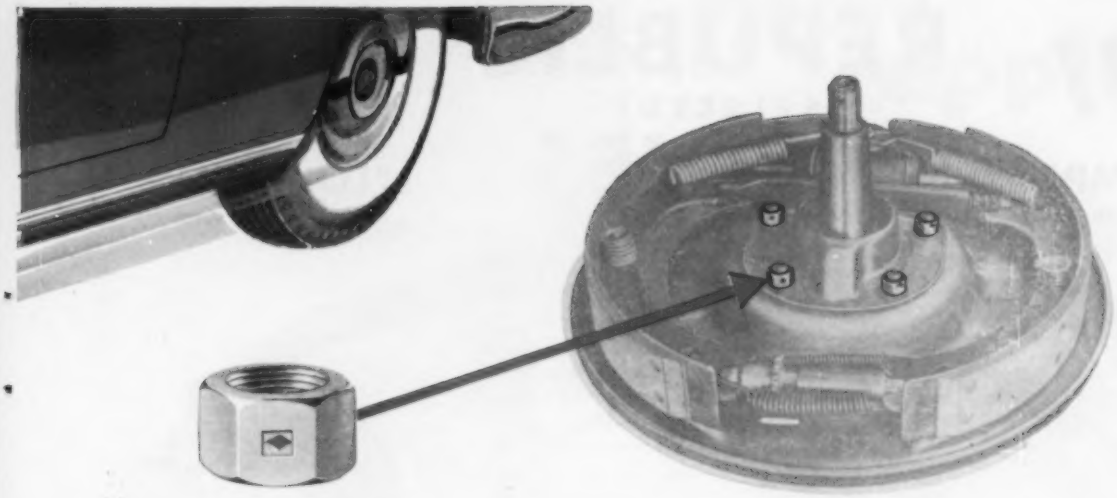
This rear axle assembly must withstand shock and vibration at high speeds. Republic "Nylok" Nuts are used to assure positive locking even under severe vibration. The nylon plug in one face forces the nut tight against the opposite threads of the stud as the nut is turned on.

Republic "Nylok" Nuts lock whether seated or not. They go on easily. Either end is up. Feed them automatically at full production speed. Or manually for piece-work. No special tools, lubricants or techniques are needed.

They cut maintenance costs, too. Republic "Nylok" Nuts are easily backed off for inspection of parts. And, then can be re-used.

REPUBLIC

World's Widest Range of Standard



vibration is a problem...

"NYLOK" NUTS!

12 WAYS BETTER

Assemble from either end • Can be re-used • Non-galling • Best wrenching characteristics • One-piece • Cold-forged • Won't damage threads • No special tools • Lock in any position • No special know-how • No lubricants needed • Ideal for mechanical feeding

SIZES

Finished Series tapped ¼" through 1"
Finished Thick Series tapped ¼" through ½"
Heavy Series tapped ¼" through 1"

Write for a sample indicating size required.

"Nylok" *Nuts are only one of more than 20,000 types and styles of high quality fasteners made by Republic for all industries.

*U. S. Pat. No. 2,462,603 and No. 2,430,694 and pending applications.

STEEL

Steels and Steel Products

These gears were made at less cost from Republic Cold Drawn Special Sections. Much of the machining was eliminated because the sections already were formed to the predominating cross-section of the part. Parts benefit from the increased physicals produced by cold drawing. The bright smooth finish rarely requires further machining. Send samples or blueprints of your parts. We will tell you whether you can save money—and how much—by making your steel parts from Republic Special Sections.

REPUBLIC STEEL CORPORATION
3150 East 45th Street,
Cleveland 27, Ohio

REPUBLIC STEEL

☐ Please send a sample "NYLOK" Nut Size_____
Please send literature on: ☐ Electro Paintlok Sheets
☐ Enduro Stainless Steel ☐ Cold Drawn Special Sections

Name_____ Title_____

Company_____

Address_____

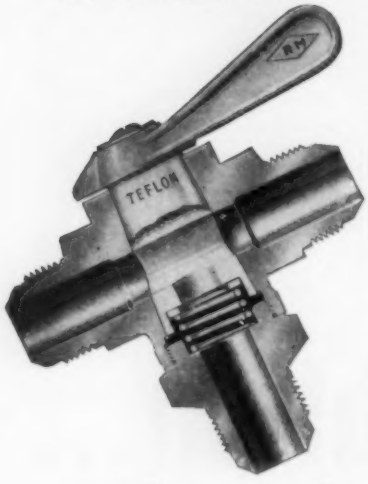
City_____ Zone____ State_____

K-7507

NEW! REPUBLIC SELECTOR VALVES NEW!

"LO-TEMP"
−65° without lubricant

"LO-TORQ"
6000 psi service



LO-TORQ SELECTOR

BALANCED PRESSURE
FOR EASY TURNING

With service pressure and seals on both sides of valving disk, turning is easy. Design is simple—maintenance is low. Many services—Air, and gas 4000 psi; fuel, hydraulic oil, petroleum, water, 6000 psi. Made in bronze, semi-steel, aluminum alloy, in three different portings, ⅛" to 1". Request Bulletin No. 454.

LO-TEMP SELECTOR

Teflon plug ends the need for lubricant. Easy turning—non seizing. −65° to 250°F. 2- 3- 4-way. 100 psi service. Made in aluminum alloy or stainless steel. ⅛" to 1" pipe or tube. Request Bulletin No. 754.

145

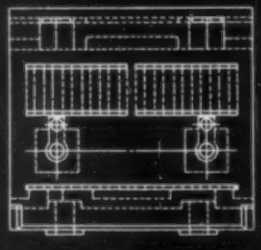
RM

REPUBLIC MANUFACTURING CO.

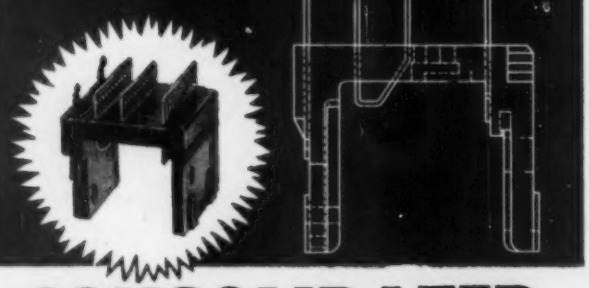
15655 BROOKPARK ROAD • CLEVELAND 11, OHIO

CMP **"Your Blueprint In Plastics"**

ALL MATERIALS • ALL PROCESSES



Custom Molding



CONSOLIDATED
MOLDED PRODUCTS CORPORATION

SCRANTON 2, PENNA.

VULCAN
ELECTRIC HEATING UNITS

Vulcan Ring Heaters

The same standard construction as Vulcan cartridge and strip heaters. Coil of highest grade resistance wire is supported in and insulated from sheath by refractories of proven quality.

Easily installed by clamping against the surface of hot plates, pots, defrosters, vulcanizers, moulds, dies, water heaters, etc.

Rust-resisting sheath for temperatures to 750° F.

Stainless steel sheath for temperatures to 1200° F.

6 standard sizes
Special sizes available.

VULCAN ELECTRIC COMPANY
DANVERS 18, MASS.

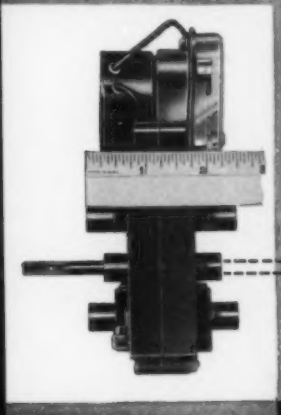
Electric Heating Units. Electric Soldering Tools. Electric Solder Pots and Glue Pots. Electric Branding Irons.

See 8-page Vulcan Catalog in Sweet's Product Engineering File for 1955.

new appliance timer by Cramer

an accurate and dependable device to control major appliances or other sequenced operations.

Shallow construction for application flexibility.

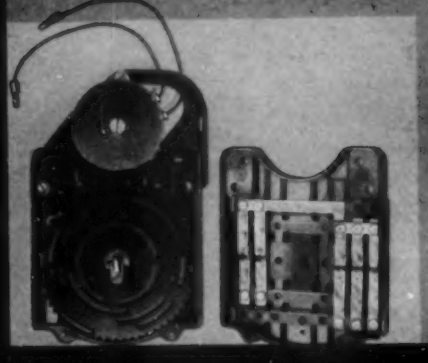


Clockwise or counter clockwise shaft rotation. Locking mechanism prevents reverse motion.

Shaft can extend from either side.

Powerful Cramer synchronous motor, rated at 30 in. oz. at 1 r.p.m.

Molded cam tracks provide infinite number of time programs.



Matched housing sections assure permanently aligned assembly.

• • • a new concept in timer design by Constantine.

Utilizing tough industrial plastics, the timer's basic feature is a simple one-piece cam with program-determining tracks integrally molded on both sides. The problem of multiple cam keying is completely eliminated. Contact pairs are mounted on a single half of the case; proper relationship is maintained even if the timer is opened for inspection. Shallow construction of the timer permits installation in restricted areas, e.g. splash aprons. No special linkage is required and the appliance control knob can be connected directly to the timer operating shaft. A complete line of timers controlling up to 12 circuits has been designed.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

BOX 7 CENTERBROOK CONNECTICUT

Follow this line

to

New Savings

The OXWELD Automatic Tracer is an accurate, economical motive power unit for oxygen-cutting machines. It is easy to set up and operate. No special tools are needed for templet cutting—they can be cut from VINYLITE plastic sheets with a knife or shears.

With an OXWELD Automatic Tracer

Trade-Mark

MAKES OXYGEN-CUTTING FAST, EASY and ACCURATE

Fast, clean, and accurate—that's how parts produced by automatic tracer-guided cutting machines come off the production line . . . Whether the job is cutting a wide range of simple patterns or intricate shapes, hundreds at a time or one piece—the OXWELD Automatic Tracer reproduces all templet designs exactly, and economically.

No need to allow for kerf in the size of templets—you merely set a dial to compensate for the kerf width of the nozzle in use. Parts are reproduced to tolerances ranging from plus or minus 7/32-in. to 1/16-in.—clean and smooth, and at high speeds.

Simple to set up—no special tools are required for making templets, they can be cut from VINYLITE plastic sheets with a knife or shears . . . The templet is simply mounted on the tracing table with masking tape. Your LINDE representative will be glad to discuss your needs, and help you determine the best setups for your oxygen-cutting operations. Start saving now—call him today for more information.

LINDE AIR PRODUCTS COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Principal Cities

In Canada: DOMINION OXYGEN COMPANY
Division of Union Carbide Canada Limited

Linde Trade-Mark

The terms "Oxweld," "Linde," and "Vinylite" are registered trade-marks of Union Carbide and Carbon Corporation.

Precision "O" Rings make these Quick-Connect couplings leak-proof!

Hydraulic, pneumatic and other fluid lines can be connected or disconnected quickly, easily and safely with the two-way shut-off couplings made by **The Hansen Manufacturing Company** of Cleveland. When connected the Hansen coupling permits a free flow through it—and a **Precision "O" Ring** makes the vital seal which insures a long life of leak-proof service.

Everywhere **Precision "O" Rings** are doing a big job, carefully inspected, high quality, tough, compression molded, they lick leakage! Let us help you.

FREE—Write for your personal copy of our Handbook on "O" Rings.

Precision Rubber Products CORPORATION

"O" Ring and Dyna-seal® Specialists

Dept 3 Oakridge Drive, Dayton 7, Ohio **Canadian Plant at: Ste. Therese de Blainville, Quebec**

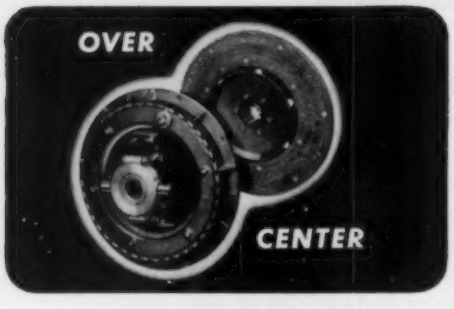
all FLEXIBLE and RIGID PLASTIC EXTRUSIONS

Tool and Button Rods up to 2" diam.
Tubing up to 4½" O.D. any wall thickness.
Copolymer Sheeting 54" wide any thickness.
Polyethylene Tubing & Sheeting, from ½ mil. up.
Vinyl Tubing, Cord, special shapes.

GERING

GERING PRODUCTS, INC. Kenilworth, N. J.
EXTRUDED PRODUCTS DIVISION

ROCKFORD



FOR HAND LEVER OPERATION

EASY OPERATION
HIGH TORQUE
POSITIVE ENGAGEMENT
LARGE DRIVING AREA
SMOOTH RUNNING
INFREQUENT ADJUSTMENT
MINIMUM INERTIA

• Anti-friction ROLLER CAMS — an exclusive feature — make ROCKFORD Over-Center CLUTCH operation extremely easy. A light pressure, lever-controlled, toggle-joint arrangement moves the high point of the cams "over center". Let ROCKFORD engineers show you how this and other ROCKFORD Over Center CLUTCH advantages will benefit your product.

Send for This Handy Bulletin
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD CLUTCH DIVISION BORG-WARNER
▲ 209 Catherine Street, Rockford, Illinois, U.S.A. ▲

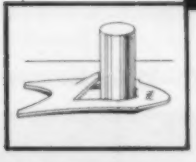
CLUTCHES

Cut Costs—Improve Fastening

of die-cast metal Nameplates, Medallions, Grilles, etc.

TYPE "F" for 3/32", 1/8" and 3/16" unthreaded studs

PUSHNUTS
Trademark



Write for free samples and literature

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THE PALNUT COMPANY
65 Cordier St.,
Irvington 11, N. J.

In Canada:
P. L. Robertson Co., Ltd.
Milton, Ont.

• **Easy, fast assembly.** Slide smoothly down the stud, then instantly lock with push of screw driver or special applicator—hand or power.

• **No stud damage.** Resilient locking tab does not grip stud until final locking action at base. Less strain on studs—no metal "shavings" to impair full resilient locking.

• **Lock absolutely tight**—even on slippery chrome plated studs. Energized spring locking grip can not loosen or rattle.

• **Can be removed.** Simply lift tab with any pointed tool. An important feature when necessary to remove defective or improperly assembled nameplates or for refinishing.

They modernized the phone...

Here's how they modernized the booth

A leading West Coast metal fabricator is helping to make the classical varnished-wood phone booth as obsolete as the hand-crank telephone. Important factor in the redesign of this familiar landmark was the availability of *custom-designed* Harvey Aluminum extrusions, which make up the frame and doors of the new booth.

Booths are now fabricated in fewer steps and can be shipped knocked-down in compact cartons. Installation at the site takes only minutes, with just four screws required for complete assembly. The design blends with the decor of modern stores and lobbies, and, best of all, the completely weatherproof booth can be installed out-of-doors, where wooden booths deteriorated rapidly. Aluminum construction makes roadside phone service practical. Such *double* benefits . . . a product both better to make and better to use . . . follow naturally when you use a Harvey extrusion, *custom-designed* for your product.

The Men of Harvey have a single objective... making aluminum work for *you*. Harvey extrusions are a *custom* product . . . each is the result of a Harvey Field Engineer sitting down with the customer's designers and jointly planning how the product can be improved with this modern metal form. Our newest brochure "Aluminum Extrusions" is a valuable reference source. We will be glad to send you a copy.

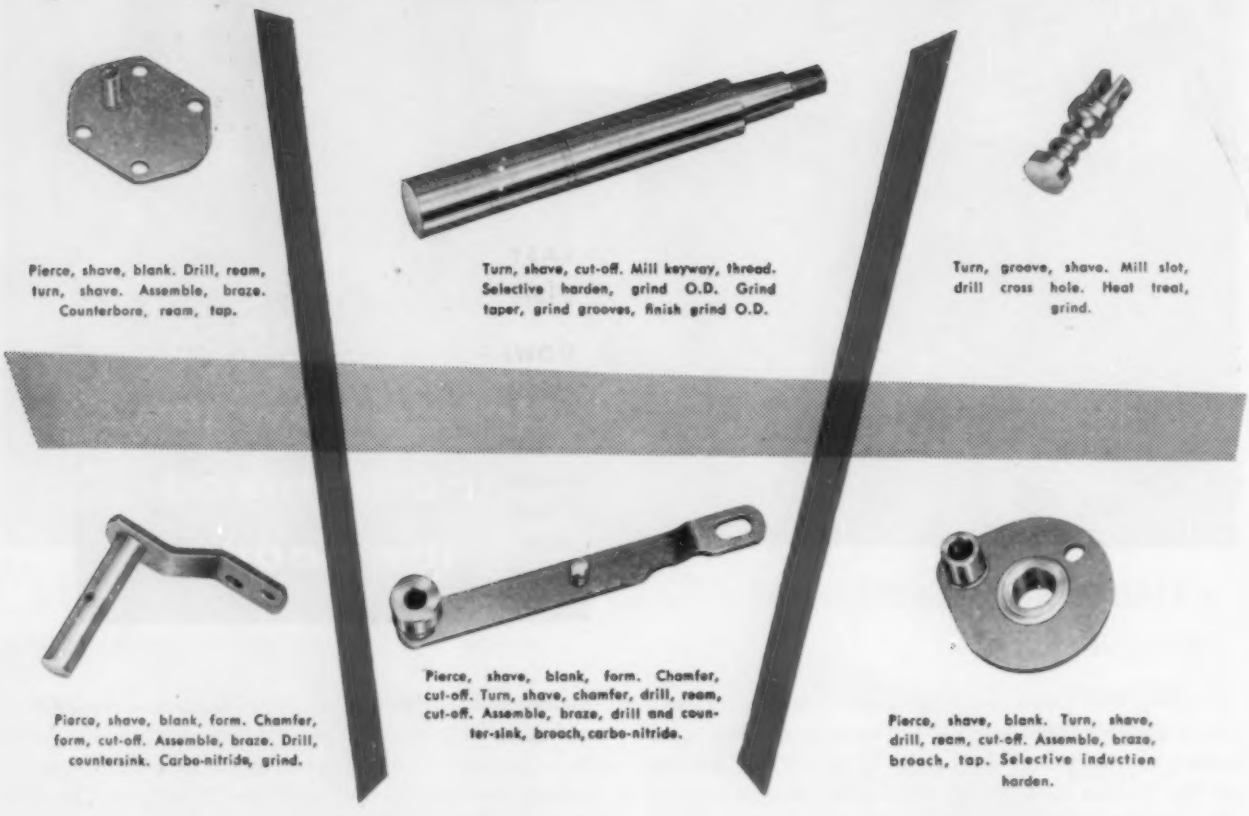
MAKING THE MOST OF ALUMINUM . . . FOR EVERYONE

HARVEY Aluminum

HARVEY ALUMINUM SALES, INC., TORRANCE, CALIFORNIA
BRANCH OFFICES IN PRINCIPAL CITIES

An independent producer of aluminum extrusions in all alloys and all sizes: special extrusions, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tubes, impact extrusions, aluminum screw machine products and related products. Also alloy steel and titanium of similar products on application.

Burgess-Norton experience and facilities made possible cost reduction and better performance on this wide variety of hydraulic components.



Pierce, shave, blank. Drill, ream, turn, shave. Assemble, braze. Counterbore, ream, tap.

Turn, shave, cut-off. Mill keyway, thread. Selective harden, grind O.D. Grind taper, grind grooves, finish grind O.D.

Turn, groove, shave. Mill slot, drill cross hole. Heat treat, grind.

Pierce, shave, blank, form. Chamfer, form, cut-off. Assemble, braze. Drill, countersink. Carbo-nitride, grind.

Pierce, shave, blank, form. Chamfer, cut-off. Turn, shave, chamfer, drill, ream, cut-off. Assemble, braze, drill and counter-sink, broach, carbo-nitride.

Pierce, shave, blank. Turn, shave, drill, ream, cut-off. Assemble, braze, broach, tap. Selective induction harden.

These are among the many precision parts for a variety of industries that are being produced more efficiently because of the combination of wide experience and exceptionally complete facilities at Burgess-Norton.

For many years these facilities have been used primarily for production of precision parts for the highly competitive automotive industry. In recent years, however, many other industries are utilizing these facilities to reduce parts costs, and improve quality.

The problems of production, investment in floor space and capital equipment to produce the part in their own plant are eliminated.

Our engineering, metallurgical and production staffs are available without obligation, to determine how Burgess-Norton may help you in your specific parts problem.

Send prints, specifications, or, if you prefer, one of our representatives will call, at your convenience.

BURGESS-NORTON MFG. CO.

GENEVA, ILLINOIS

SERVING INDUSTRY FOR OVER FIFTY YEARS

Why users prefer GARLOCK

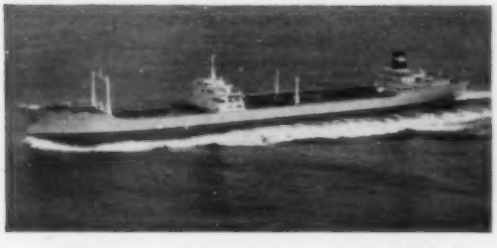
SPLIT-KLOZURE

OIL SEALS

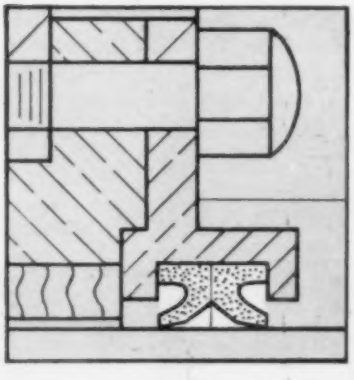
For Heavy Equipment

1. EASY TO INSTALL ON THE SHAFT WITHOUT DISMANTLING HEAVY MACHINERY

2. DOWN-TIME AND REPAIR COSTS ARE REDUCED TO A MINIMUM



The 45,000 ton tanker, "World Glory," built at Bethlehem Steel's Quincy yard, is the largest ever built in the Western Hemisphere. The rudder stock bearings, upper and lower pintle, are protected by Split-KLOZURE Oil Seals.



Cross section shows the dual opposed Split-KLOZURE assembly on the rudder post of the "World Glory." This dependable, easy-to-install seal keeps vital lubricants *inside* the rudder trunk's voids, keeps seawater *out*.

*KLOZURE is a registered trademark for Garlock oil and grease seals.

The construction of the Garlock Split-KLOZURE* permits easy and quick application in inaccessible locations. Instead of applying over the end of the shaft or journal—as is necessary with solid, one-piece seals—the Split-KLOZURE is placed *around* the shaft or journal. This can be done at any convenient place near the bore or housing into which the seal is to be applied.

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*For complete details on Garlock Split-*KLOZURES, *write today for bulletin AD-124.*

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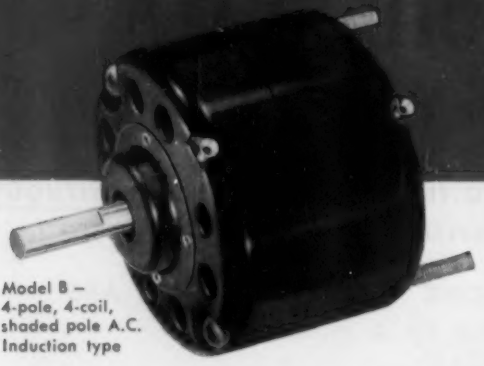

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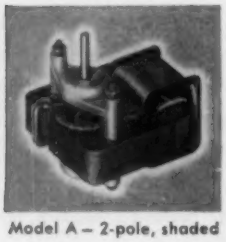
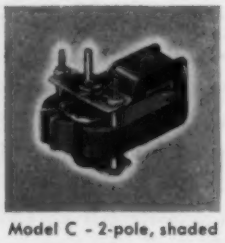
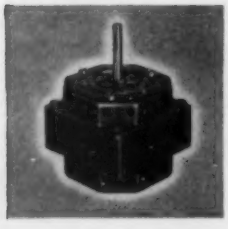


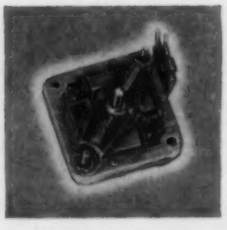
Model A – 2-pole, shaded pole A.C. Induction type



Model C - 2-pole, shaded pole A.C. Induction type



Model D — 4-pole, 4-coil, shaded pole A.C. Induction type



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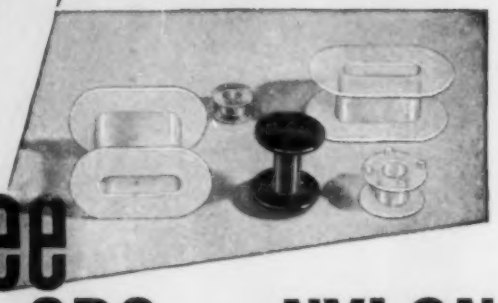

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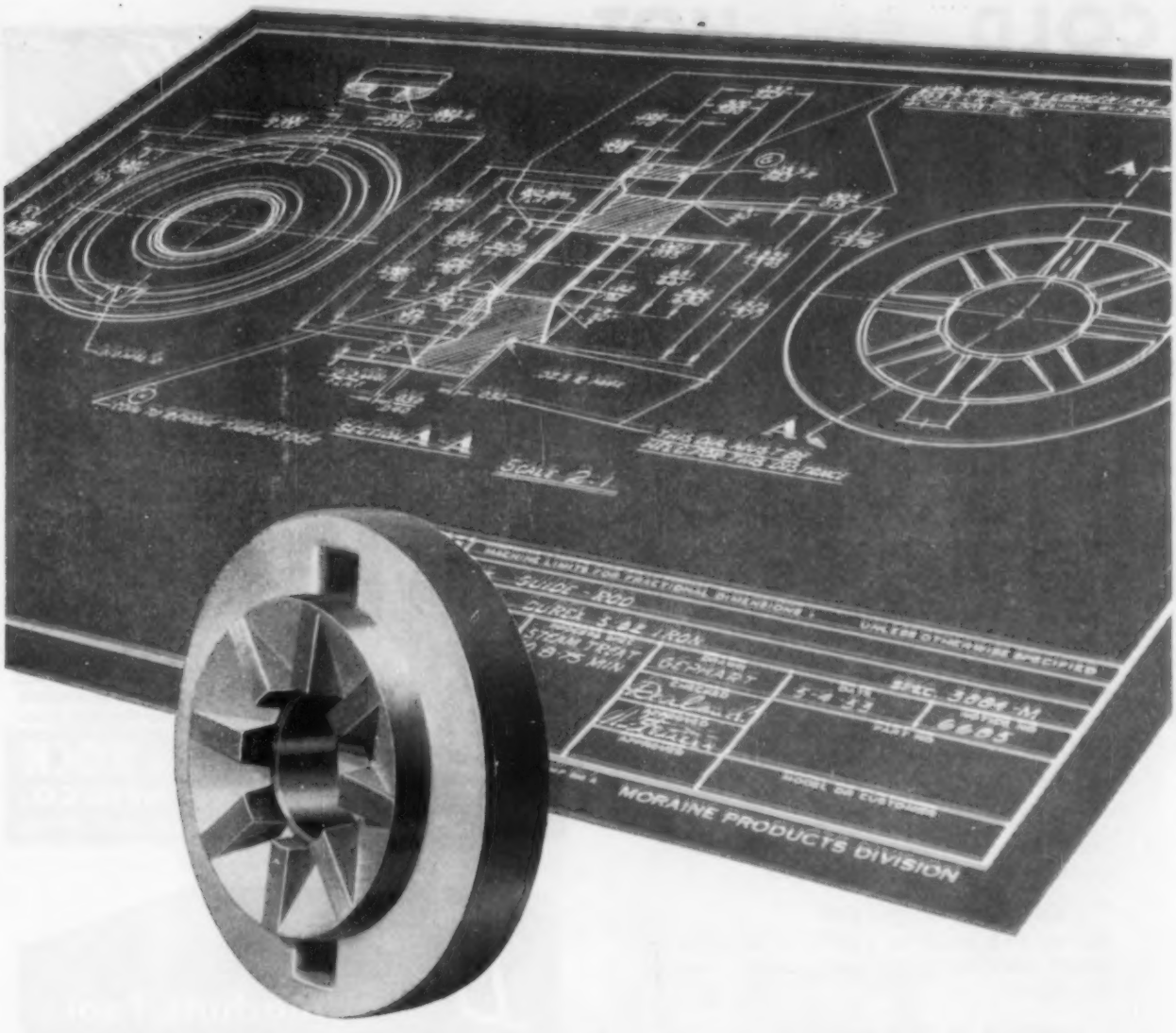

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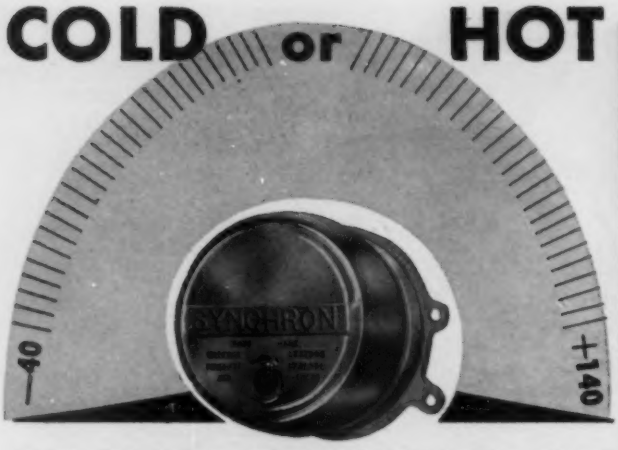

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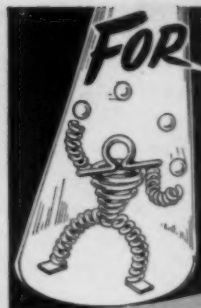

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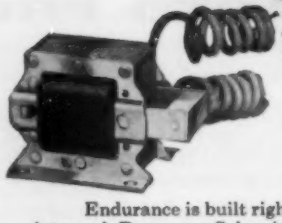

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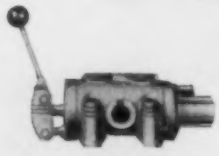

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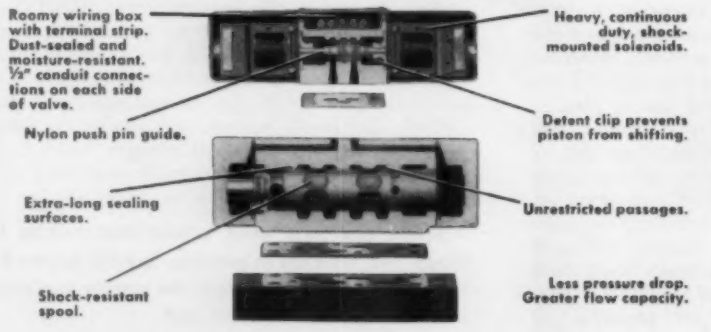
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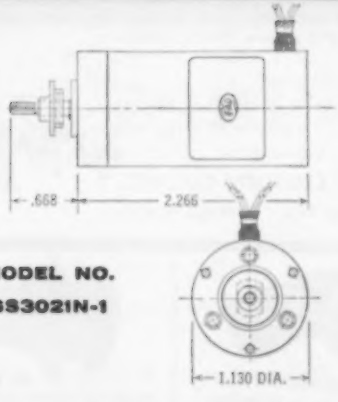

MODEL NO.
GS3021N-1

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Input Voltage	115	Stall Torque	7 oz. in.
Phase	2	Rated Torque	3 oz. in.
Frequency	400 cycles	Size	1 1/8" dia.
No Load Speed	180 rpm		2 17/64" long
Full Load Speed	135 rpm	Gear Reduction	28.4
Rotor Inertia	1.25 gm. cm²	Weight	4 1/2 oz.
		Duty	Continuous

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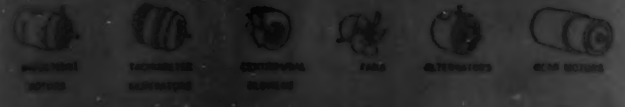

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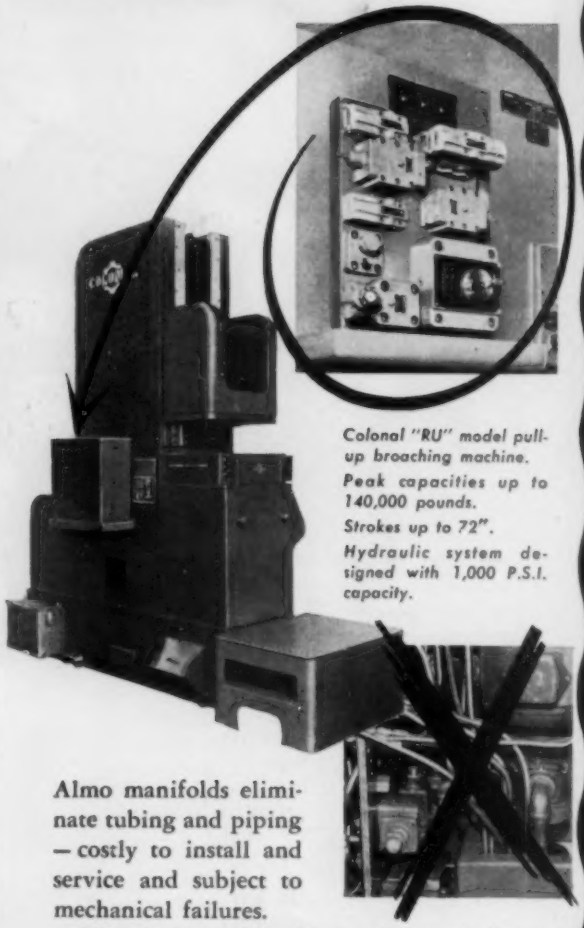

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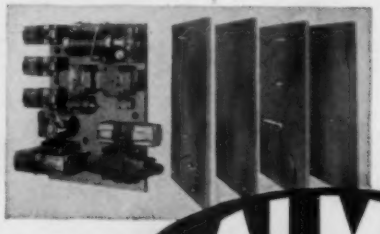

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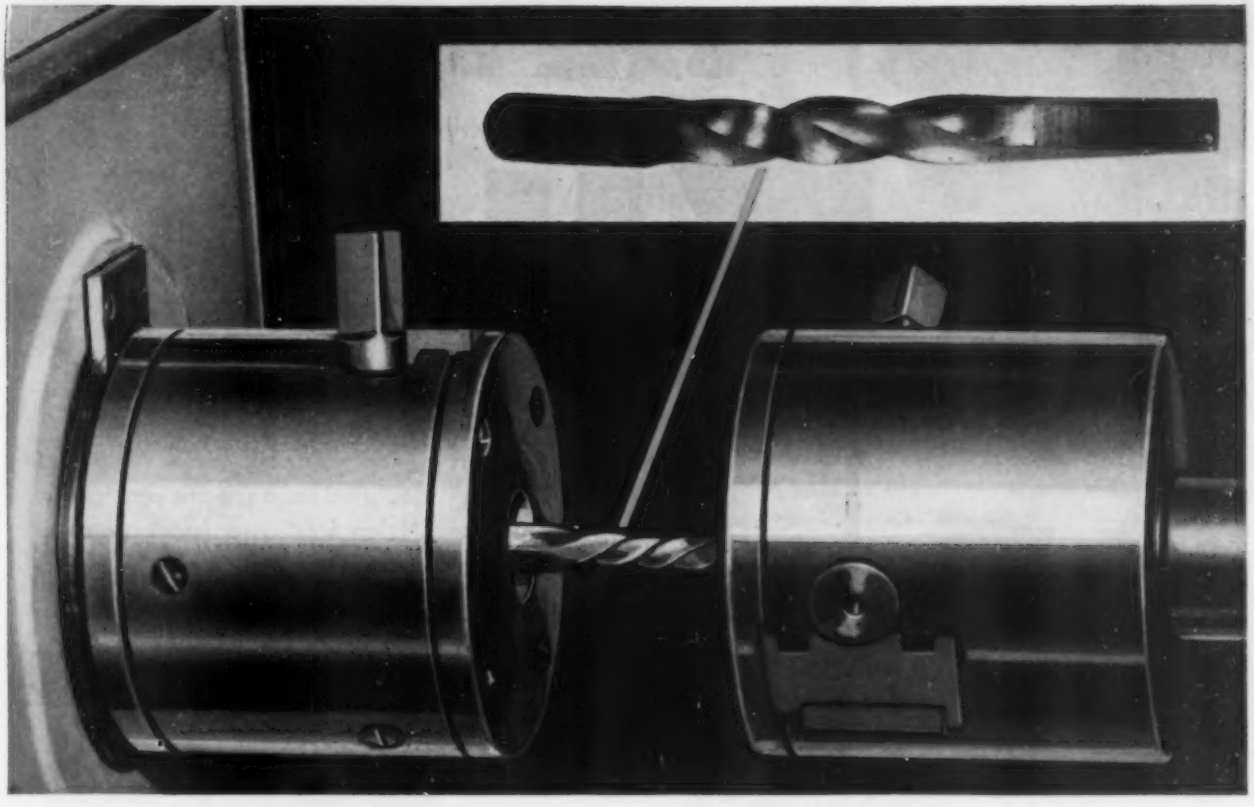

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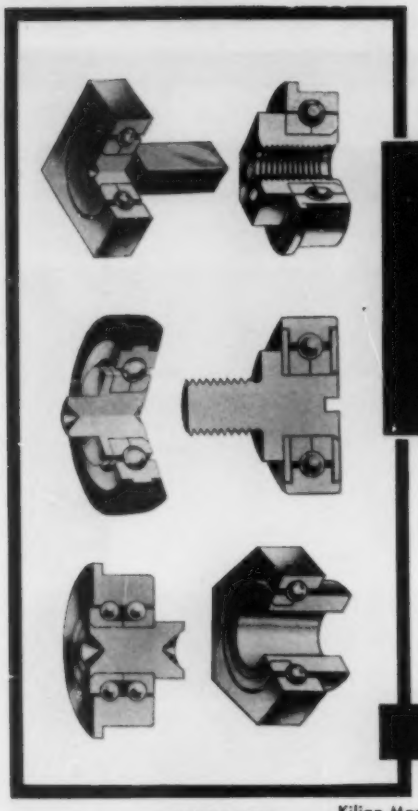

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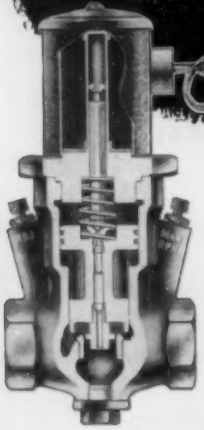

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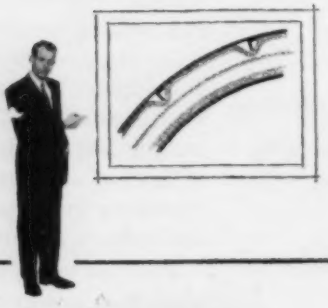


FELT
by FELTERS

DOES THE JOB RIGHT

For a good slip-fit without rattling or looseness, Felters Felt is an ideal design material. To insulate against heat or cold, there are grades of Felters Felt to solve many knotty problems.

If you would like information about felt's versatility in solving design problems, write to Felters. Our 16-page "Felt Design Book" describes many interesting problems that have been successfully solved by Felters Felt. Write for your free copy. THE FELTERS CO., 228 South St., Boston 11, Mass.

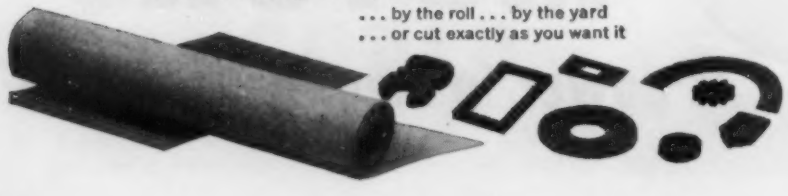
FELTERS S.A.E. FELTS F-10, F-11 & F-13

are often used for oil or grease retention where the felt is compressed or confined in an assembly. Where operating conditions are not too severe, these grades are also used to make dust shields.

These are 3 of many grades of Felters Felt produced for specific applications.

FELTERS FELT

... by the roll ... by the yard
... or cut exactly as you want it



It's the new ADVANCE SQ—a telephone type that hits a new high in ruggedness and efficiency!

Only 15 milliwatts per pole will operate the new SQ relay in the DPDT combination. Here is sensitivity teamed with stable performance—the DPDT unit withstands 10 G's vibration from 10 to 500 cycles. When power is increased to 40 milliwatts per pole, vibration resistance rises to 30 G's. A single-coil relay, the ADVANCE SQ is available in 1- to 5-amp contact ratings, and in contact combinations from SPST to 6PDT. It comes through Signal Corps tumbling and shock tests in excess of 200 G's with operating characteristics unimpaired.

Sustained efficiency keynotes SQ operation. The use of a beryllium copper armature retaining spring insures positive contact between armature and pivot points at all times. Cross-bar palladium contacts are always properly aligned. A wide variety of coil resistances is feasible. Instead of organic insulation, the unit employs Silicone glass, Kel-F, or Teflon tubing. Life expectancy for 5-amp, non-inductive loads is 150,000 cycles... for 1-amp, non-inductive load: 1,000,000 cycles.

Open type dimensions are 1" x ¾" x 1¹⁵⁄₁₆". DPDT units are supplied in a sealed container measuring 1" x 1" x 2". Write for literature on the SQ series.

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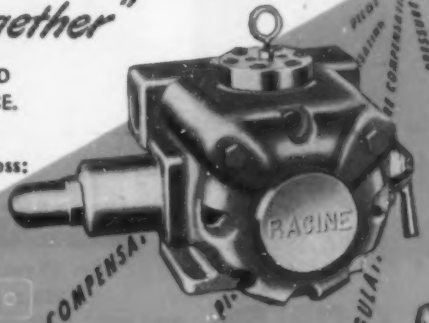

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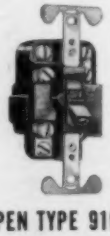
NEW CUTLER-HAMMER 9101
TWO-POLE MOTOR SWITCH

Better Control and Protection for All Motors up to 1 HP

Check these features and know the difference: Twin-break solid silver contacts; quick make and quick break. All mechanical operating parts are stainless steel. Famous Cutler-Hammer Eutectic Type thermal overload protection. Free-tripping; contacts cannot be held closed. Resets when switch is thrown to off position. Motor load sensing coils are fully enclosed but front removable; available for 10% loading increments.

Easiest to install and wire; removing wrap-around cover exposes mechanism completely, at front and both sides. Cover secured by single self-retained screw which cannot drop out and become lost. No annoying loose insulating baffle. Straight-through wiring; line terminals at top and load terminals at bottom . . . all clearly marked. Switch mechanism so compact it can be used in ordinary wall switch outlet box with standard toggle switch plate. Ideal for flush mounting on wall, panel or in machine cavity. Your Authorized Cutler-Hammer Distributor stocks both single pole and two-pole models of the new C-H 9101 Motor Switch. Order today and see the difference. CUTLER-HAMMER, Inc., 1332 St. Paul Ave., Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer, Ltd., Toronto.

EASY TO WIRE
Removing wrap-around cover opens switch at front and both sides.



OPEN TYPE 9101
Ideal for flush mounting on wall, on any panel or in a machine cavity.

CUTLER-HAMMER

CUTLER-HAMMER
MOTOR CONTROL
C-H

Here is the nut that resists stress, wear and vibration

Extra holding power need not add to the cost of any assembly. Gripco Lock Nuts are of one-piece design—thus low in initial cost. Their faster application reduces production costs, their greater holding power reduces mechanical wear and failures, which means longer product life for greater customer satisfaction. The Gripco Lock Nut, with triangular depressions on its top, provides frictional resistance to vibration and permits repeated removal and reapplication. The locking action is produced by a simple, vertical thread deflection, inherent in the nut itself—the same design that has held threaded fasteners tighter for over 50 years. If stress, wear or vibration poses a fastening problem for your products, see how a Gripco Lock Nut can give you a tighter hold, longer wear. Impervious to oil or water. Write for samples and full particulars.

GRIPCO PRODUCTS INCLUDE:

Gripco Lock Nuts, New Gripco "Clinch" Nuts, Gripco Hi-Nuts, Gripco Pilot-Projection and Countersunk Weld Nuts with or without Gripco locking feature.

GRIP NUT COMPANY

"after 50 years still holding strong"

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DESIGNERS—

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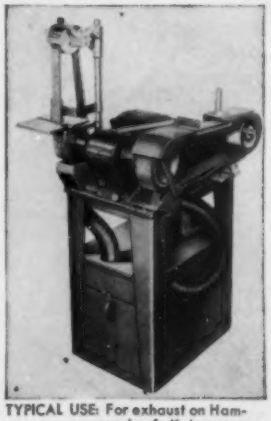

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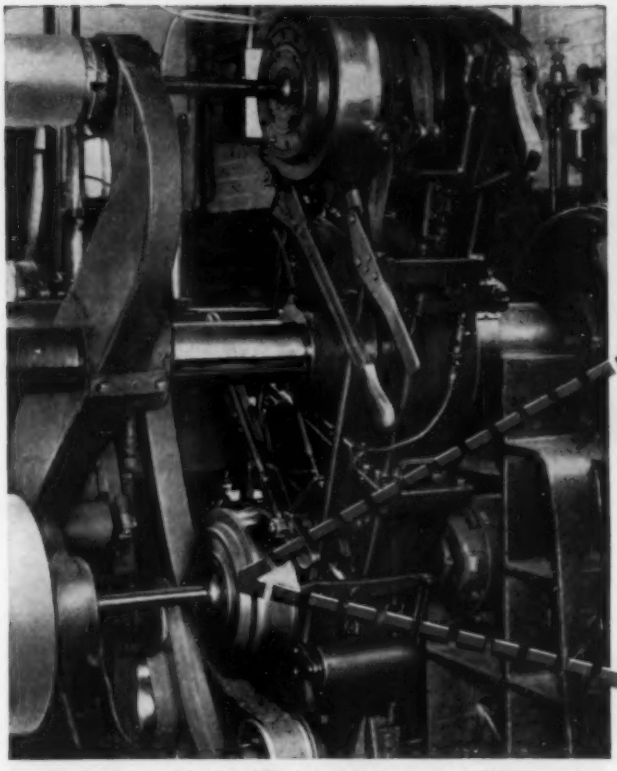
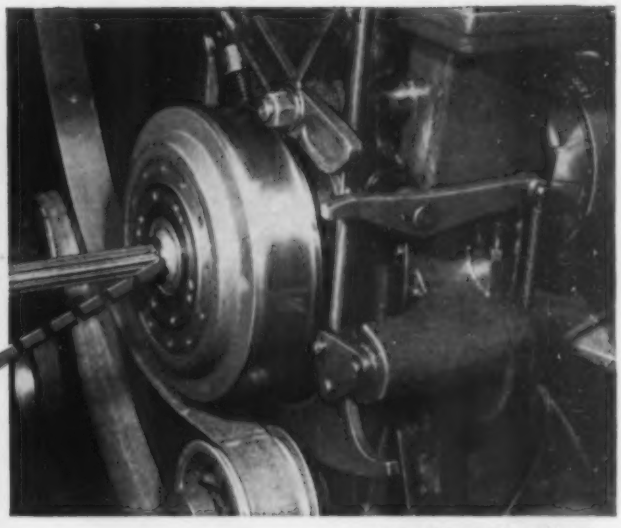
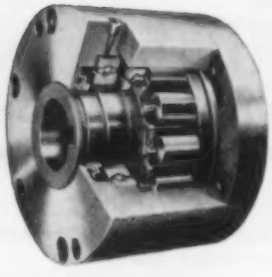


The Black-Clawson Model 42 Winder, used in paper-winding operations by Appleton Coated Paper Co., Appleton, Wisconsin.



Two Morse Cam Clutches are used on each arm of the Model 42 Winder.



Cutaway view of adaptable Morse Cam Clutch.

Morse Cam Clutches run 61,320 hours without repair in unique paper-winding operation

Two Morse Cam Clutches are employed in each of the two arms of the Black-Clawson Model 42 Winder, as used by the Appleton Coated Paper Co., Appleton, Wisconsin. In the process of winding rolls of paper as it comes from the drying oven, these clutches have been used for seven years of continuous 24-hour service (61,320 hours)—requiring only minor repairs at the end of that time!

The Morse K Series Cam Clutch does the driving when the regular reel motor drives a roll of paper in the winding operation. It overruns when a roll change occurs, allowing the new core to be brought up to speed by a speeder belt motor, independently of the main drive. This allows the critical surface speed of the paper to remain identical, although the R.P.M.'s of the core and roll differ.

Morse Cam Clutches are available in 5 design types, covering a wide range of design applications. Simple in design and easily installed, each Morse Cam Clutch is, in effect, a self-contained ratchet with an infinite number of teeth, more accurate than a ratchet and pawl mechanism. With its full cam design, it combines maximum torque with minimum space requirements for indexing, overrunning and backstop applications.

Write for data-packed catalog binder, for complete engineering and dimensional data on the Morse 200-Series Cam Clutch.

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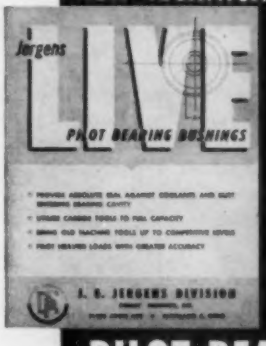

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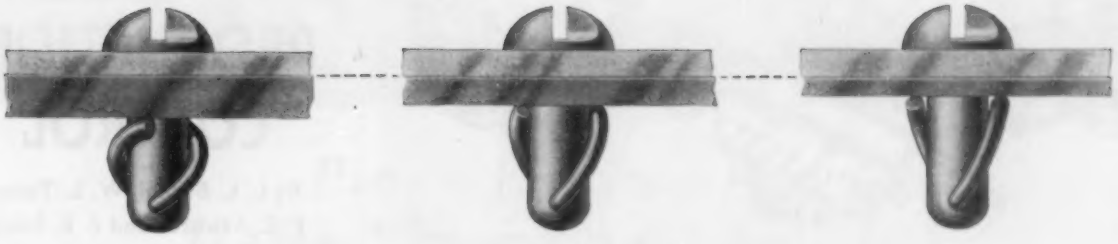

Spring-Lock—the easy-to-use removable fastener for modern designs—works whether panel thicknesses run over or under specifications! Spring wire deflects automatically to handle greater or lesser thicknesses. Spring-Lock's design flexibility makes it more than a fastener: it can be adapted as a shelf support, door strike, knob or any similar panel-mounted device. Many standard shapes and sizes of Simmons Spring-Locks are available from stock.

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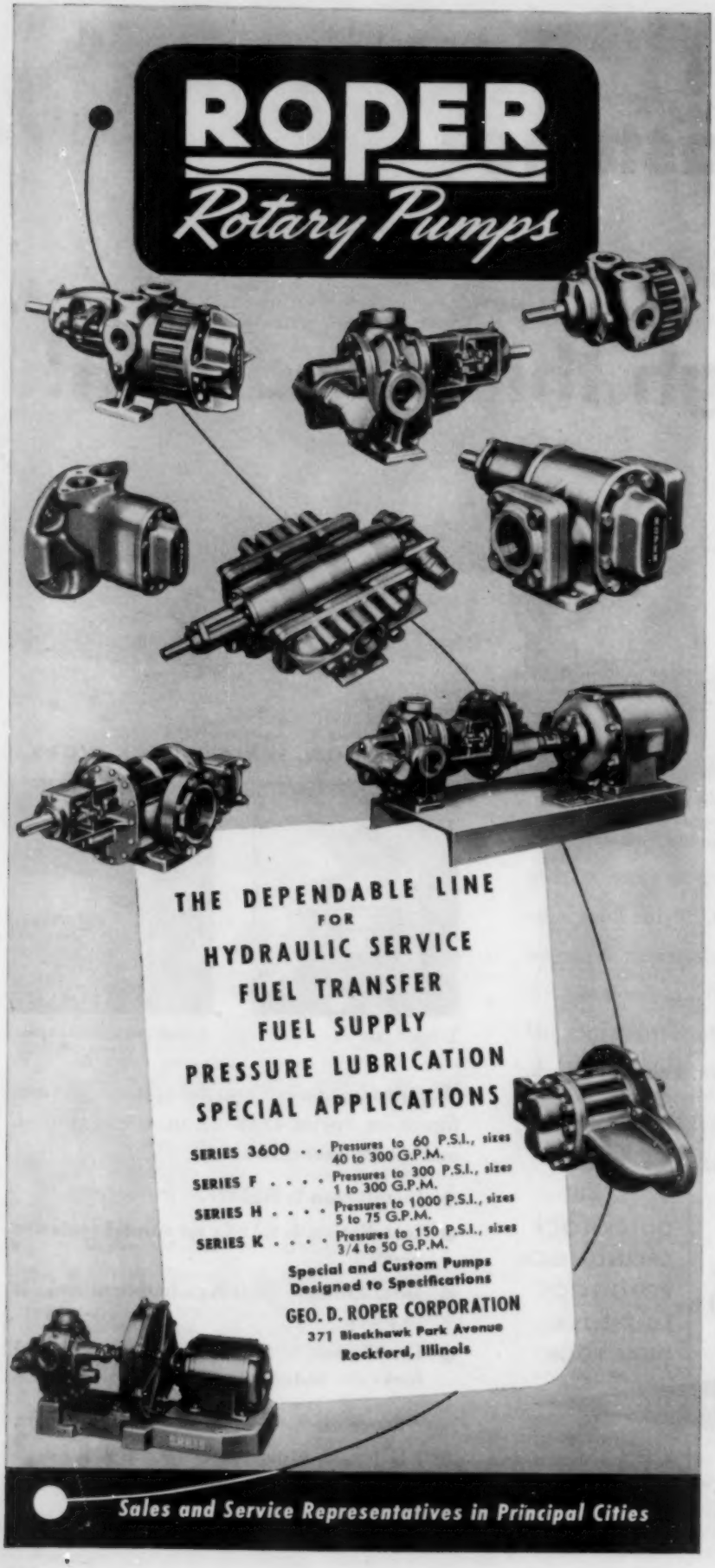
1. *Insert fastener.*

2. *Half-turn locks it in place.*

With production costs on the uptrend, you can figure on Spring-Lock as an assembly time and money-saver, because:

- **Installation is BLIND**
- **Installation is EASY: no special tools are needed**
- **Installation is QUICK: a half-turn locks it in place**
- **Installation is SECURE: the *spring* steel *locks* the fastener, resists vibration**

Send for details and samples, or write us about *your* fastening problem.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Closeup of mandrel, Ampco-coated steel balls fill tube during bending, prevent walls from collapsing.

Completed bend in Pines Precision Bending Machine.

Pines Engineering licks "impossible" job

. . . bends ultra-thin stainless tubing

. . . cuts airplane costs $14,000

thanks to **AMPCO* METAL**

AIRCRAFT engineers said that cold bending of thin-wall tubing sections for engine and airframe components was impossible — that it couldn't be done. But Pines Engineering Co., Aurora, Illinois, went to work anyway. It developed a precision bending machine that makes smooth, sharp bends to 10" centerline radius in up to 5" diameter x .025" wall stainless tubing — bends that are cutting airplane costs up to $14,000 each.

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"Ampco eliminates the problem of pickup on the mandrel and wiper die when bending stainless steel tubing. And Ampco provides a hard-wearing surface that enables the production of thousands of bends before dies have to be refitted."

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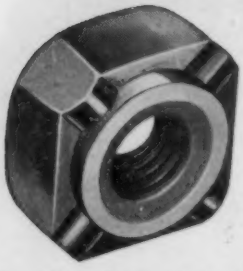

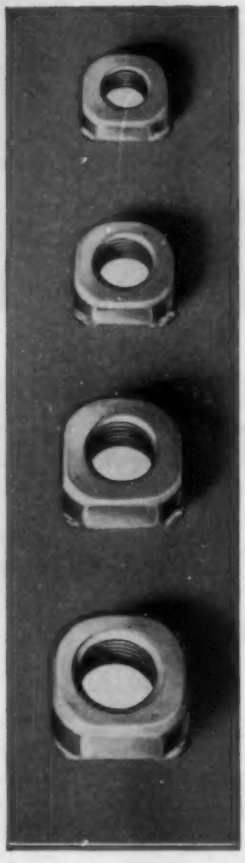

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Whether you're designing a product or building it, the Midland Welding Nut is the answer to the problem of accurately and securely fastening metal parts into a main assembly . . . speedily, economically.

It is welded to the parts so that a bolt can be turned into it without the need for any device to hold it and keep it from turning.

This frequently means that one man can do the work of two, for with an ordinary bolt and nut one man usually has to hold the nut in place while a second man turns the bolt into it.

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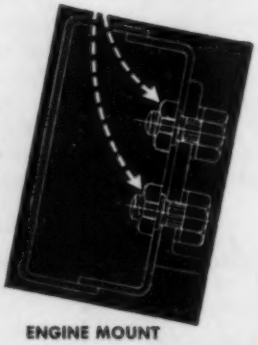
Write or phone for complete information *today!*



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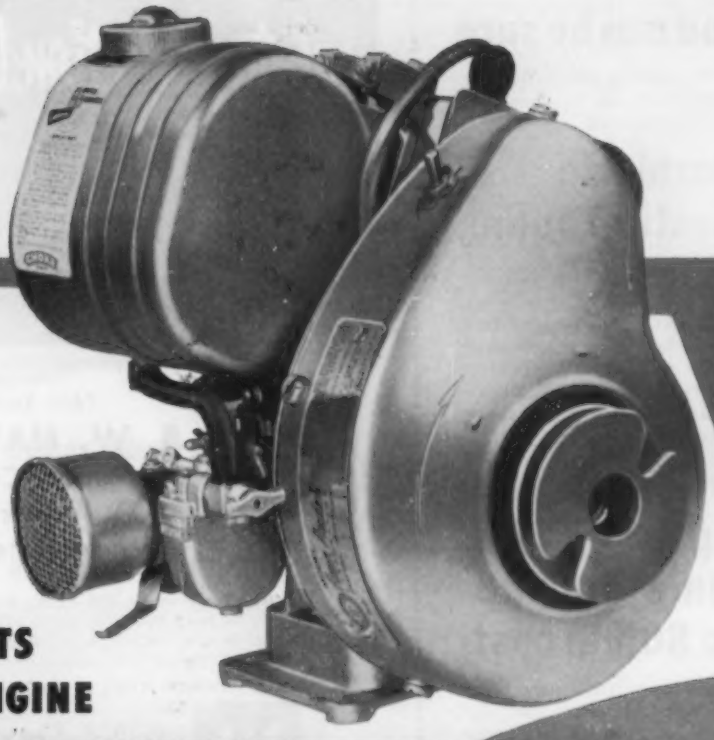

guess

THE WEIGHT of this NEW 2HP POWER PRODUCTS INDUSTRIAL ENGINE

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Here's Power Products Corporation's popular 2-cycle engine that delivers 2 horsepower.

How much would you guess it weighs? Fifty pounds? Thirty? Twenty? Guess any of these and you'd be wrong. It weighs just sixteen pounds.

This remarkable power to weight ratio is made possible, in a large measure, through the use of ball bearings at both ends of the crankshaft. Power Products engineers, like many others, recognized the inherent advantages of the 2-cycle principle—lightweight and compactness. The use of ball bearings on the crankshaft enabled them to virtually eliminate radial play with its related problems previously found in 2-cycle engines and produce a dependable small 2-cycle industrial engine.

The application of SKF bearings to this and other Power Products 2-cycle engines helps give the engines longer life, easier starting, consistent operation, as well as accurate timing, hotter spark and less friction which means more power.

SKF Field and Home Office Engineers know a lot of places where anti-friction bearings should be used to make your product better—places where their application produces benefits as it does for Power Products. Any of them, without obligation, will analyze the design of your product and perhaps show you how to make it better.

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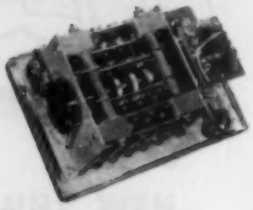

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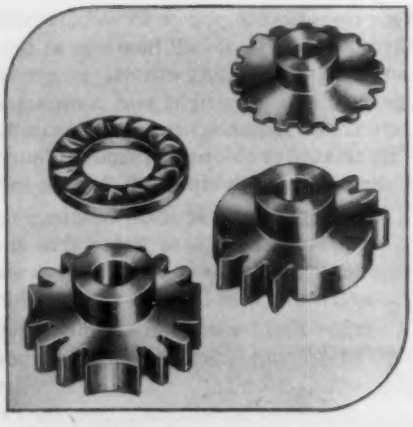

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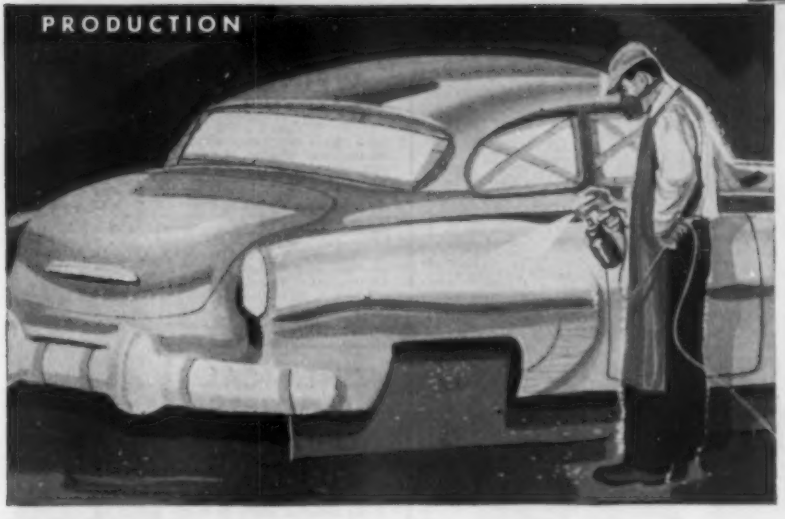

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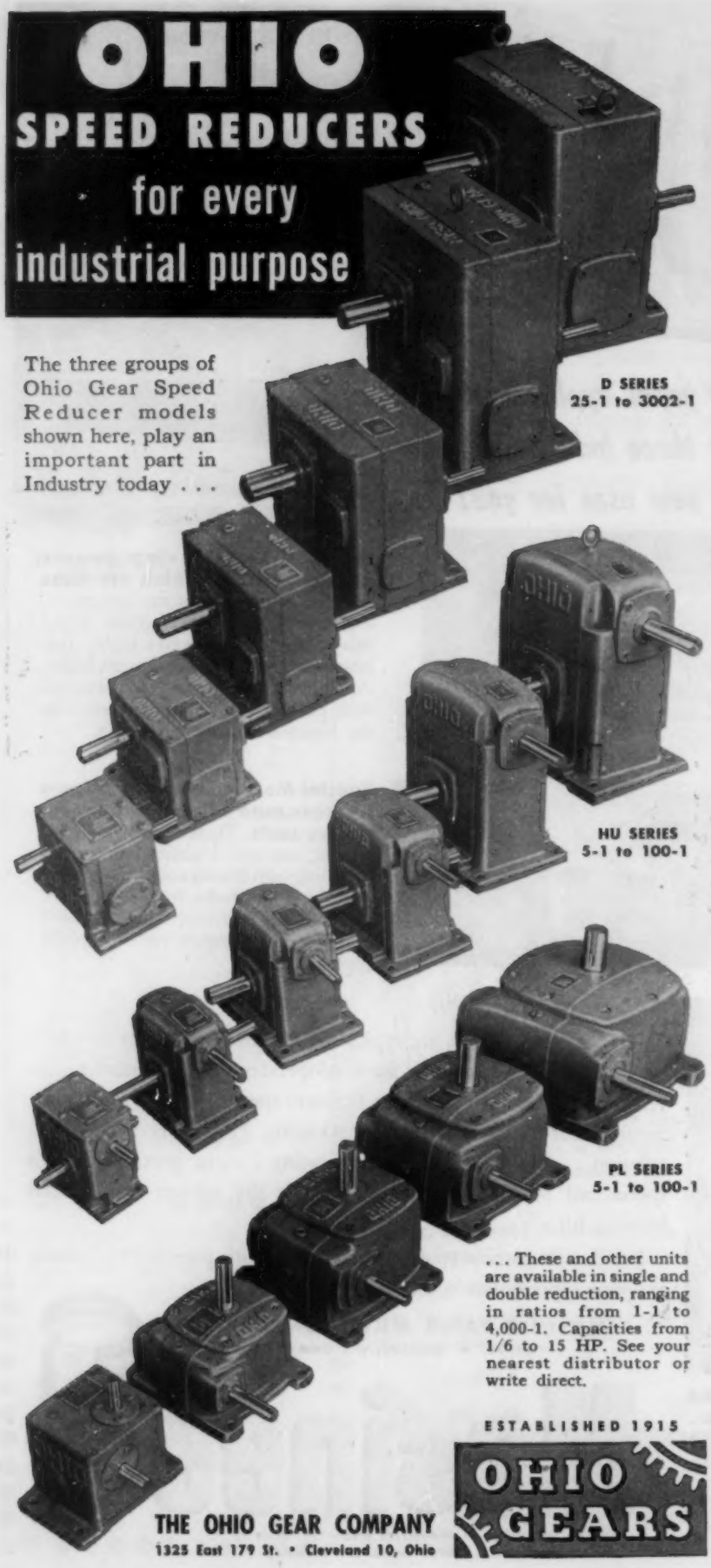

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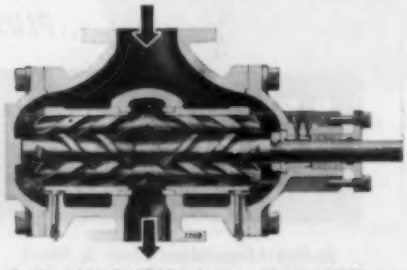

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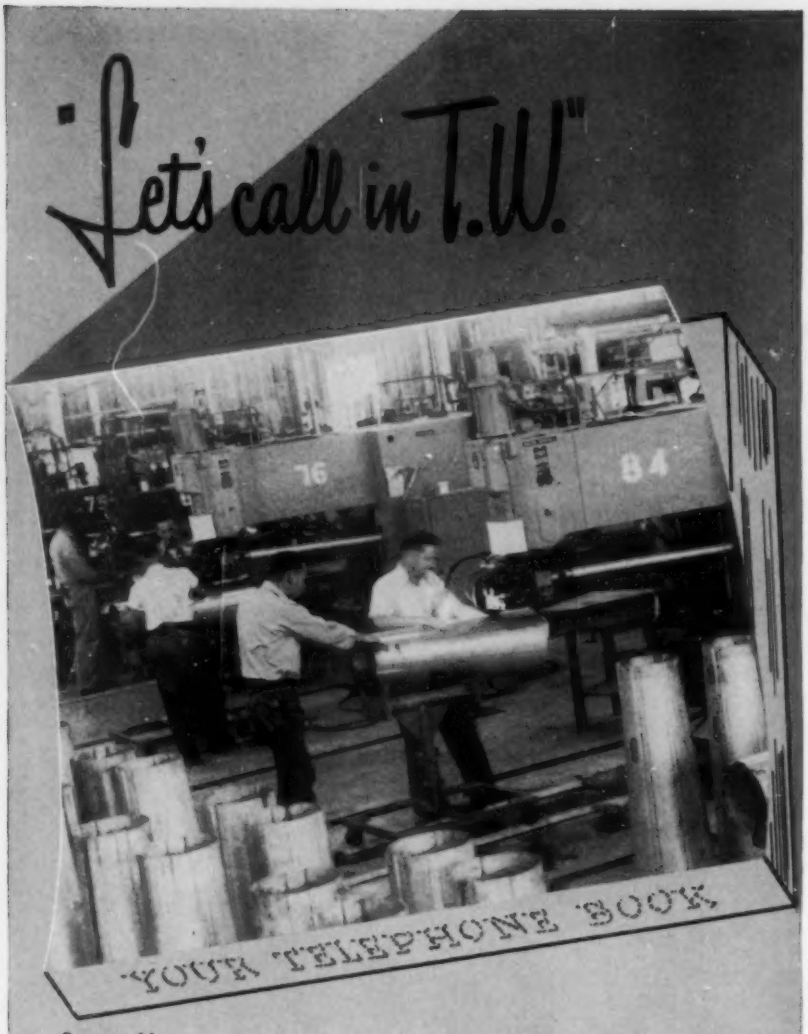

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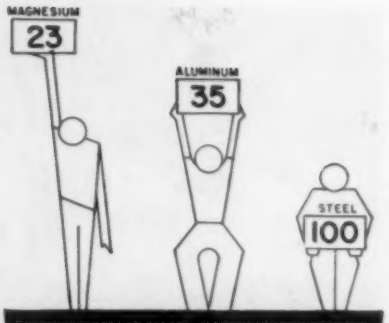

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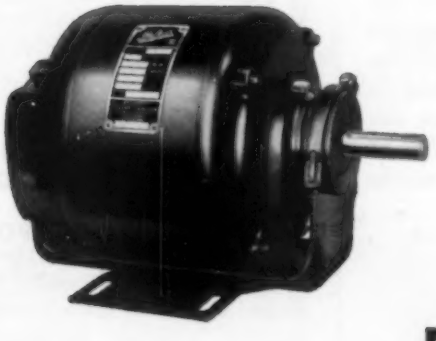

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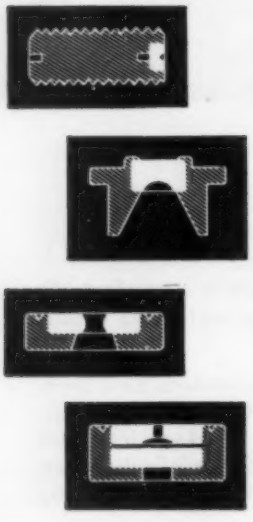

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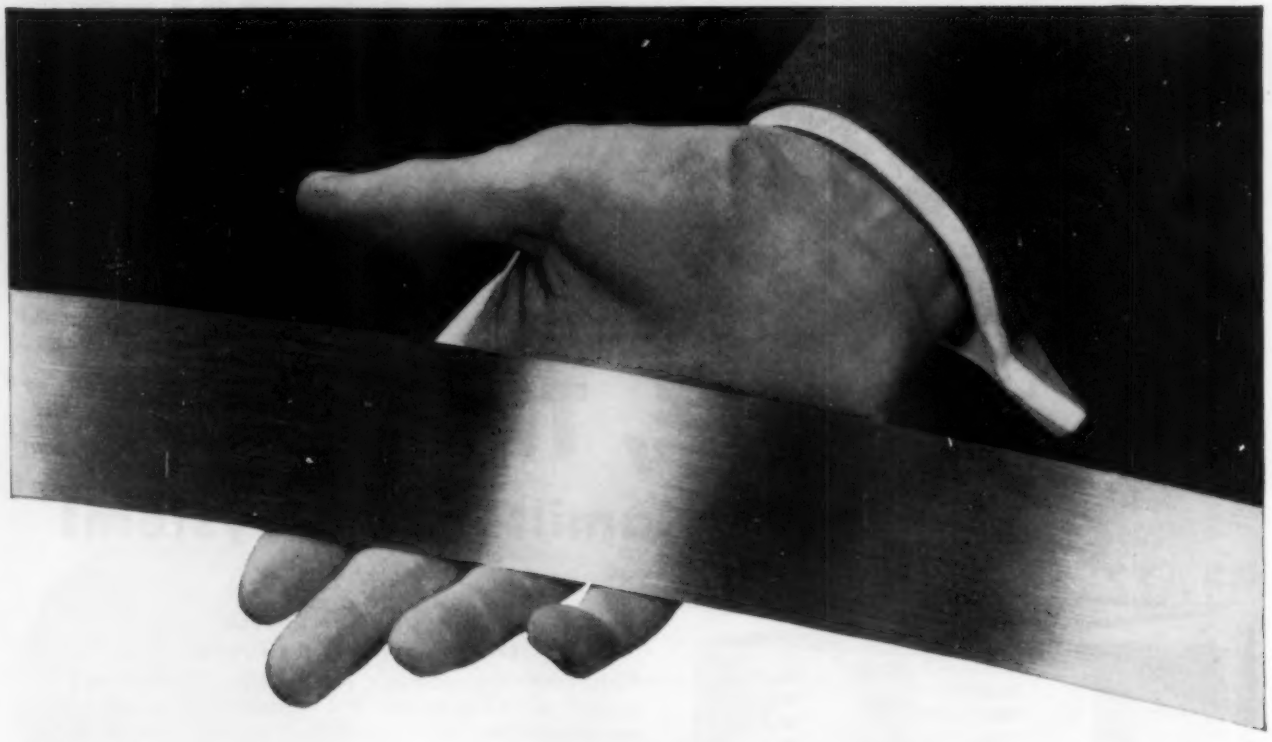

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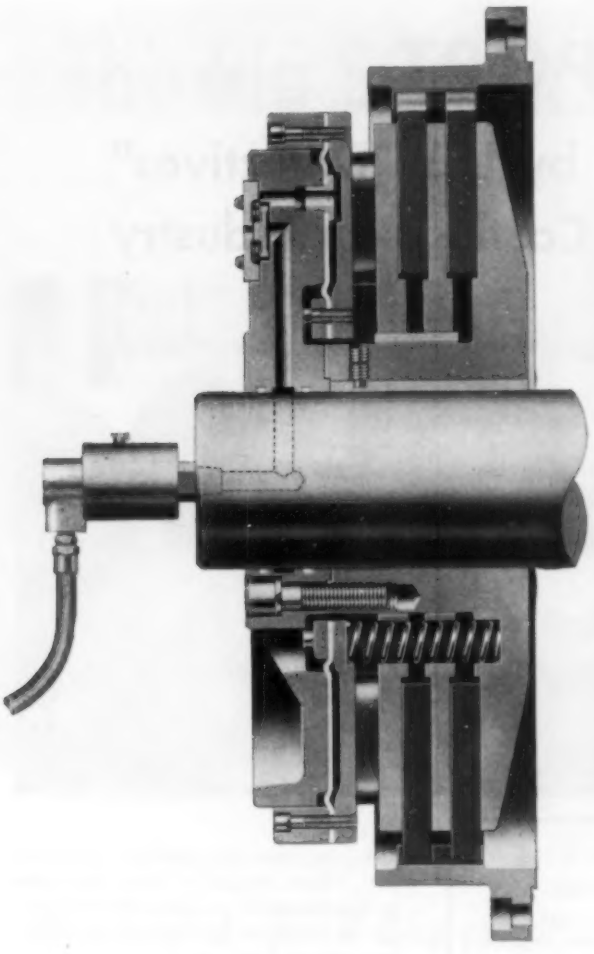

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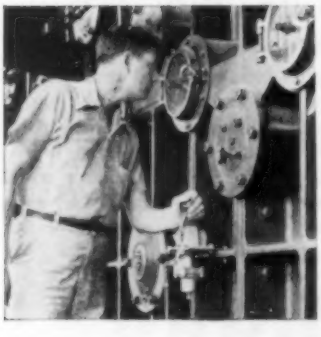

Finger tips on the throttle bring instant response, give the operator split-second control. This new product of Dodge is the quickest-acting air clutch available!

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Thorough tests in the field as well as in the laboratory assure you of Dodge dependability in the Air-Grip Clutch. Available in sizes from 8.5 to 460 hp at 100 rpm at 80 psi. Call your local Dodge Distributor or write for Bulletin A634.

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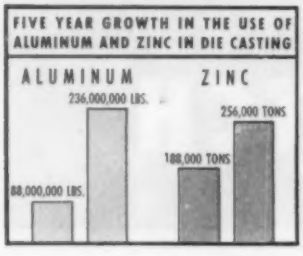
DIE CASTING REPORT ..... the first of a series

Constant Spot Checking by Lab "Detectives" Assures Sound Zinc Die Castings for Industry

Uniformity guaranteed by periodic analysis of production die casting runs

The high strength, soundness and uniformity of today's die-cast zinc parts can be attributed to the continuous and vigorous efforts of the industry itself, through the American Die-Casting Institute, to establish an alloy standards unification plan.

To assure maintenance of alloy purity, the industry sponsored the Certified Zinc Alloy plan, which put "teeth" into the industry's enforcement of standards. Recognition of improvement in alloy control is shown in steadily increasing annual production of zinc die-castings in the past five years. As the accompanying chart shows, the use of both aluminum and zinc have risen to new heights.

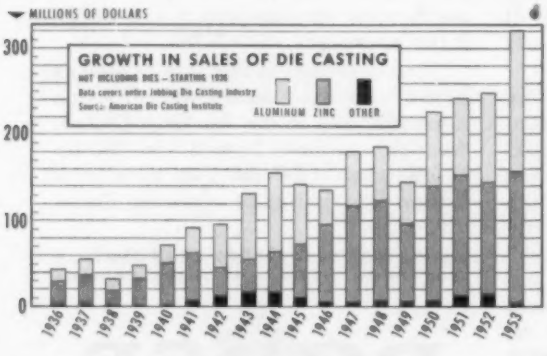


Die-casters, licensed under the C-Z plan, must submit sample castings, regularly, to independent laboratories. In addition, C-Z lab representatives periodically visit each licensed plant, *without previous warning or notice*, to select samples from die-casting machines in operation. These "detectives" then determine by spectrographic analysis whether each sample conforms to the strict chemical composition limits required in ASTM specifications. Thus, industry maintains its own "police force" for the benefit of die-cast buyers.

When you are considering the use of zinc die-castings, it is wise to check the suppliers; wiser still to deal with those who use the C-Z seal.

WHAT this seal means to the buyer of Zinc Die-Castings

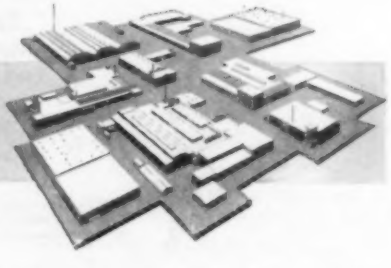
1. That high purity metal is used
2. That adequate chemical control is maintained
3. Positive identification of castings produced under the plan
4. An easy way of identifying die casters who conform to acceptable chemical control requirements in processing
5. Assurance of the mechanical and physical properties inherent in zinc die castings



AMERICAN DIE CASTING INSTITUTE
97 members represent $400 Million Industry

Now in its 26th year, this national Institute was formed to raise the standards of efficiency and improve practices in the industry. It recently organized the Die-Casting Research Foundation to further the development of new die materials and casting procedures in non-ferrous and eventually the ferrous metals. A new 16-mm color film is now available which describes the die-casting process, how to improve product design and reduce costs. Showing may be arranged by writing to us or any member of the Institute.

It will pay you to put die-casting into your product or component part planning. "Die-Castings...Unlimited" is a new 24-page brochure which details Precision's integrated services. If you would like a copy, address your inquiry to PRECISION CASTINGS CO., INC., 155 Chapel St., Fayetteville, N. Y.



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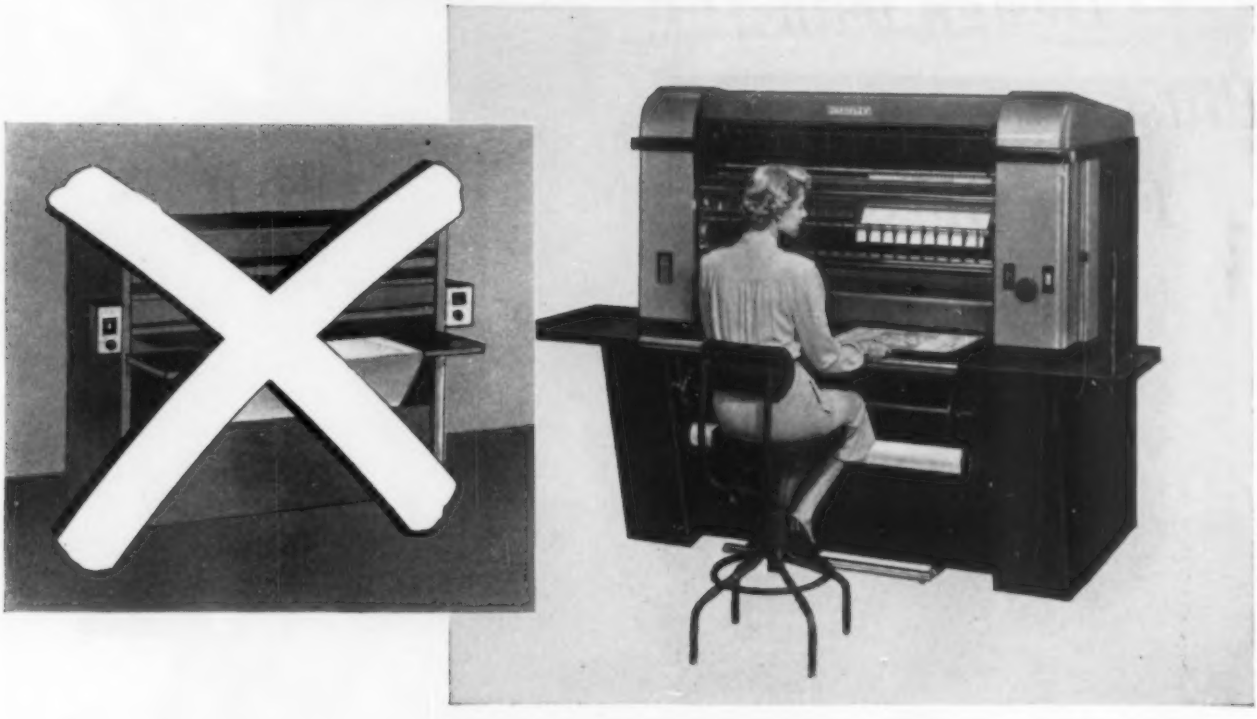

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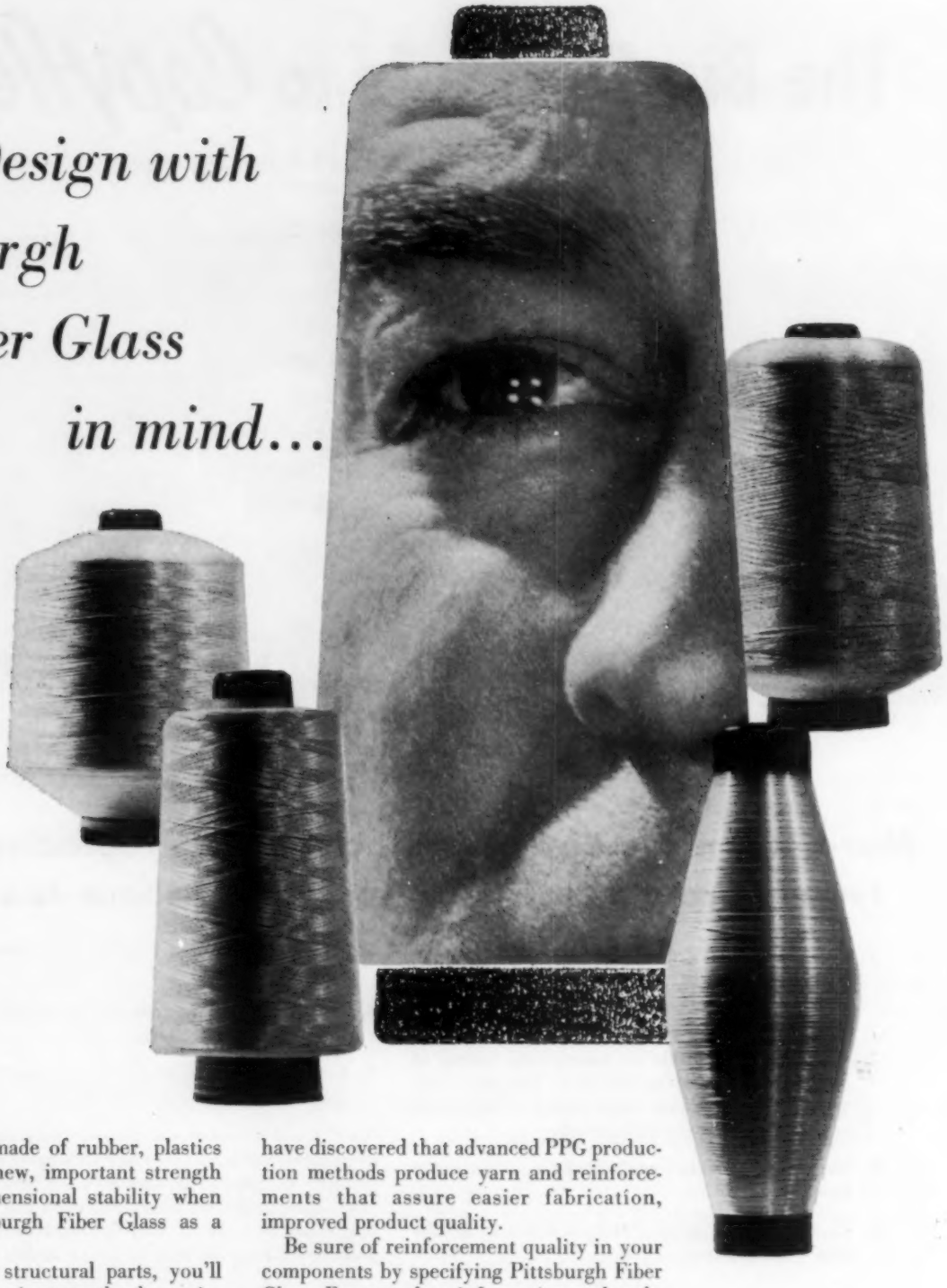
Design with Pittsburgh Fiber Glass in mind...



Component parts made of rubber, plastics or paper take on new, important strength and additional dimensional stability when you specify Pittsburgh Fiber Glass as a reinforcement.

In housing and structural parts, you'll add excellent dielectric strength when reinforcing cloth containing Pittsburgh Fiber Glass is specified for laminates used in making such parts.

Yes, the design trend is to fiber glass reinforcements—and specifically, to Pittsburgh Fiber Glass, because of its exceptional quality. Manufacturers and molders alike have discovered that advanced PPG production methods produce yarn and reinforcements that assure easier fabrication, improved product quality.

Be sure of reinforcement quality in your components by specifying Pittsburgh Fiber Glass. For complete information and technical staff assistance, write our executive offices or sales offices in Chicago, Cincinnati, Cleveland, Detroit, Houston, Los Angeles, New York, Philadelphia or St. Louis. Pittsburgh Plate Glass Company, Fiber Glass Division, One Gateway Center, Pittsburgh 22, Pennsylvania.

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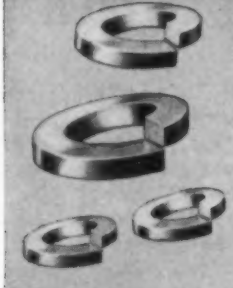
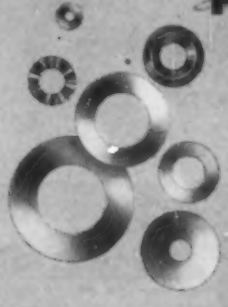


Complete line of high quality spring lock washers to ASA and SAE specifications, plus many special types . . . wide choice of metals plated to your requirements.

FLAT WASHERS



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Quick deliveries on small and medium stampings made to your specifications on high-speed precision production presses. Finished, tumbled and plated to your specifications.

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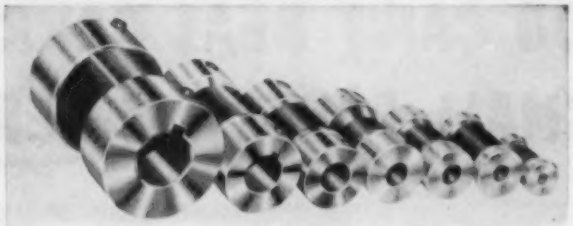
specify Guardian FLEXIBLE COUPLINGS



5R 4R 3R 2R 1R 0R 00R

Freedom of the designer to select and specify the exact length which his drive requires—*plus* very low outside diameter of coupling for the load it carries—*plus* the availability of Flex-Elements to meet special drive problems like the example given here—*plus* one-piece construction in 1/15 to 3 HP series—these are reasons for more and more OEM specifications of Guardian DYNA-LINE flexible couplings.

Our Product Application Department will welcome consideration of your coupling problem. GUARDIAN—also producers of the molded nylon splined sleeve coupling.

Write for Catalog Page C-102 and Drive Data Form #53.

FROM OUR PRODUCT APPLICATION FILE

Case History No. 25-3-R

Problem: A deposit drawer for drive-in banking activates a limit switch just before reaching the extreme limit of its travel. The momentum built up by the gearhead motor imposes approximately 50 in. lbs. upon the arrested motion of the drive train. To protect the gears against this sudden shock a flexible coupling is required which will deflect flexibly 20° in rotation under this load.

Solution: A study of the load deflection involved, with the normal running torque in this drive, found its answer in one of the several Flex-Elements available in Dyna-Line couplings. The No. 3-R in 4¼ inch length was then selected. No premium price for so-called "non-standard length".

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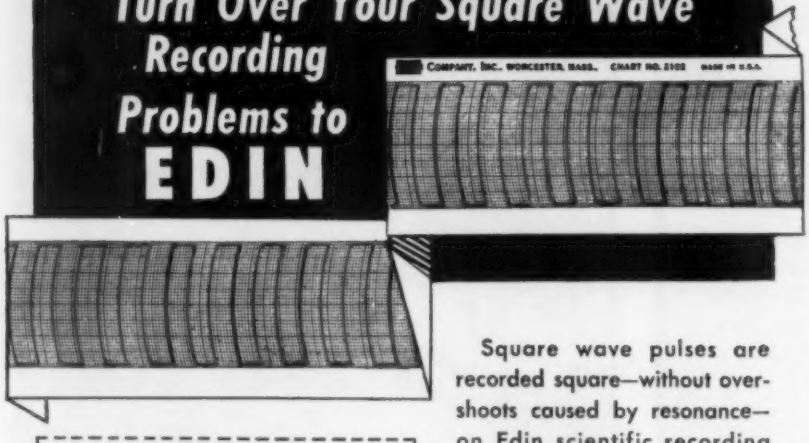

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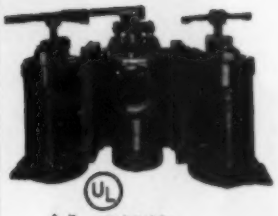
* SINCE 1920 * in the application, design and mfg. of pumps — separators — hydraulic accessories.

Simplex & Duplex SEPARATORS



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Kraissl Class 72 duplex separators are designed so that you don't need to use a lifting jack to raise the rotary plug valve. The valves are designed to a sufficiently wide angle taper — so that the plug does not wedge on its seat, through wear and use.

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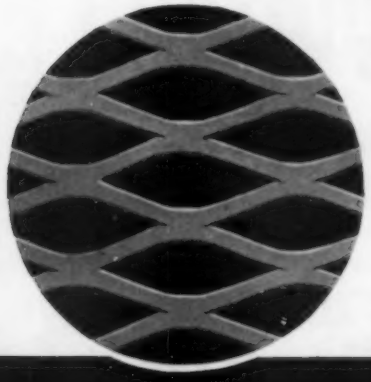

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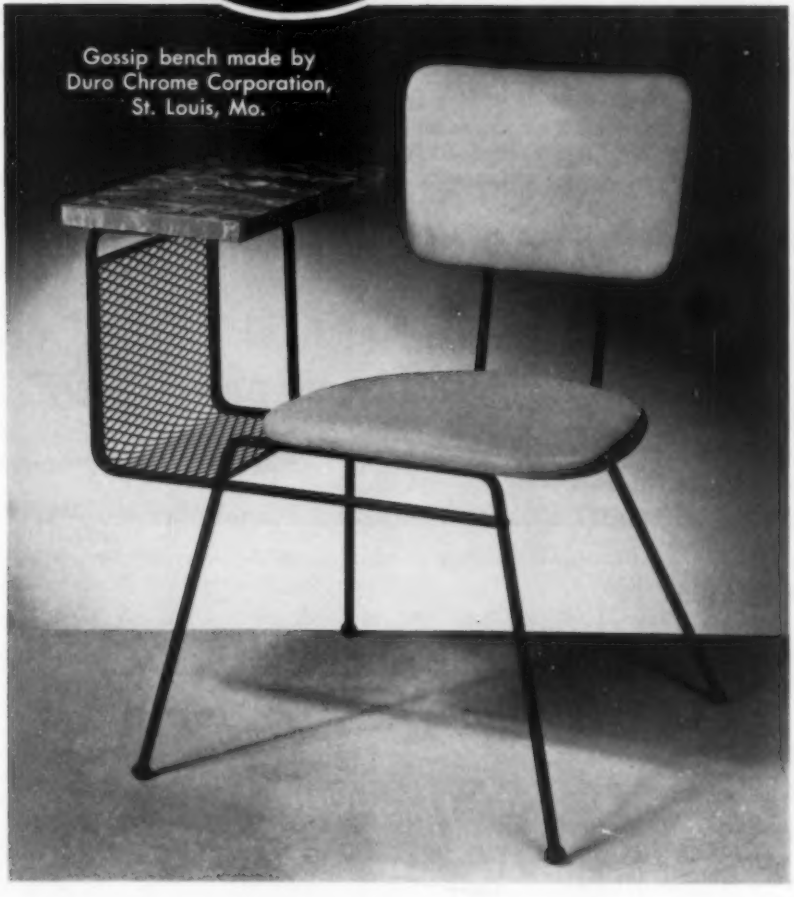

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PM-57

L&H Customized Motors Power

R-S Butterfly Valves

to Regulate Flow of Liquids and Gases,

. . . *employ* NOPAK *Cylinders controlled by* NOPAK *Operating Valves*

In the chemical, paper, petroleum and steel industries, in sewage plants, water works and other utilities, R-S Butterfly Valves are used for fast, accurate flow-control of liquids, vapors and gases. In the interest of speed and efficiency, and to reduce or eliminate manual effort, the R-S Products Corp. of Philadelphia equips many of its valves with NOPAK Air or Hydraulic Cylinders controlled by NOPAK Operating Valves.

The R-S No. 789 Butterfly Valve pictured here is typical. This successful application may suggest how you can use NOPAK Valves and Cylinders in your plant operations, or to improve the performance of equipment that you build for others.

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R-S No. 789 Heavy Duty Butterfly Valve equipped with NOPAK Model "D" 8" x 12" Air Cylinder and NOPAK Valves for optional solenoid or manual valve control.

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DESIGNED for AIR and HYDRAULIC SERVICE

Refer to Sweet's File for Product Designers or write for Bulletin SW-2.

A 7555-½H

ROTATING or STATIONARY ASSEMBLIES

held together EASIER with

SpirOlox

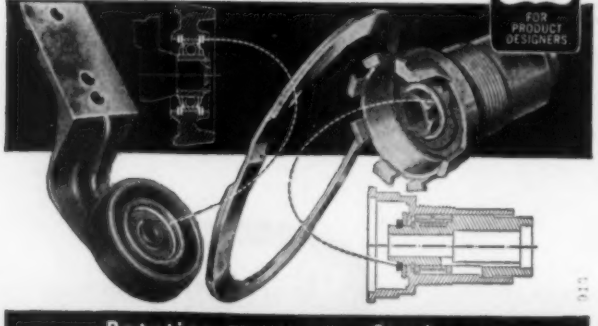
Retaining Rings

Conveyor roller application at left shows how Spirolox attains neat, compact, simplified design, even on rotating assemblies. Stationary application of lock assembly illustrates how Spirolox can be applied to hard-to-reach places where retaining ring must operate in very confined space. Secret of Spirolox adaptability is patented *two-turn* construction, which makes possible unique locking characteristic... will not jump out of groove. Always provides a uniform shoulder... no lugs, no gap.

FREE DATA BULLETIN. Send blueprint of your retaining problem. Ramsey Corp., St. Louis 8, Mo.

U. S. Pat. No. 2,450,435 and Foreign Pats. Other pats. pend.

SEE OUR CATALOG IN SWEETS FOR PRODUCT DESIGNERS



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Let us help you create such a "signature." Our skilled craftsmen, long experience and modern equipment insure finest results. Send a rough sketch or blueprint for design suggestion and quotation.

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J&H Customized Motors Power 9 Leading Floor Machines!

Low motor height with high power output gives manufacturers added sales advantages

Nine major manufacturers of floor machines came to Jack & Heintz with an industry-wide need: a low silhouette motor that would give their machines clearance under low furniture, yet retain torque and power characteristics of a conventional-size motor.

In custom designing a motor for the industry, Jack & Heintz engineers developed a special, low silhouette unit that completely answers this need.

Features Extra Shallow End Bells

The extremely low height of J&H's design is the result of extra shallow end bells with inner-bearing construction and wafer-type switch. This, in turn, permits the use of the same amount of lamination steel and copper wire as found in a conventional motor—results in comparable horsepower and performance characteristics.

Modifications Offered From Basic Special Design

A J&H Low Silhouette Motor can be furnished with one or more of the following modifications:

1. Exterior contour and finish to match styling and color of original equipment.
2. Externally or internally mounted capacitor.
3. Ratings from ¼ to 2 hp in single or dual voltage, single or three phase, and for odd current characteristics.
4. With or without special face or flange-mounting end frames (see drawings).

FLANGE MOUNT | FACE MOUNT | WITHOUT END FRAME

DESIGN YOUR PRODUCT TO DO A JOB . . .

not to fit a motor

Avoid compromising your product design by taking advantage of an engineering philosophy geared to solve your special motor needs. Design your product to do a job . . . not to fit a motor! Write Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio.

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Customized JACK & HEINTZ ELECTRIC MOTORS

New, independent source of THERMOSTAT METALS

Since 1930, makers of temperature-actuated devices were limited, in their sources of supply for thermostat metals, to those companies operating under a cross-licensed patent. As soon as that patent expired, American Silver Company entered the field.

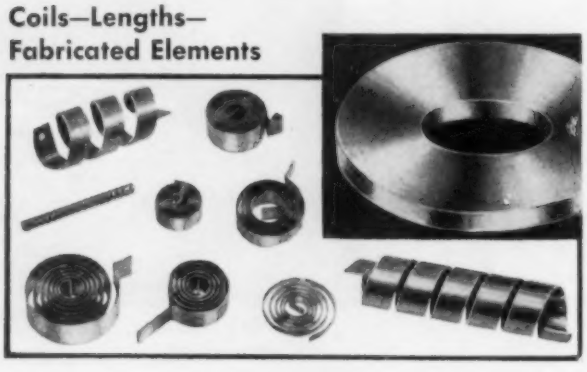
American Silver brought to the manufacture of thermostat metals its extensive experience in producing metals to exacting tolerances for the aircraft, electronics, communications, instrument and jewelry industries — where thickness tolerances as close as ±.0001" are often mandatory.

Thermostat metals are produced at American Silver on 2-high, 4-high and Sendzimir rolling mills, each specially designed to produce precision tolerance strip with high-quality surface finish. All ASC strip is continuously atmosphere annealed for maximum uniformity.

Why ASC Thermostat Metal Prices are Lower

Since the Thermostat Metals Department bears only a small part of the total overhead, production costs are exceptionally low. This substantial saving is reflected *in a lower selling price to you.*

Coils—Lengths—Fabricated Elements



Spiral and helical coils, flat blades, U-shapes, cantilever strips and other elements are fabricated to your blueprints. ASC thermostat metals are produced in thicknesses down to .001", widths down to 1/16", in coils or in lengths cut to your order.

The ASC thermostat metals now available will satisfy most requirements. New bimetals are constantly being added to the line.

Tell us what you'd like to accomplish; we'll be glad to make our recommendations. Ask for Technical Data Sheet #400.

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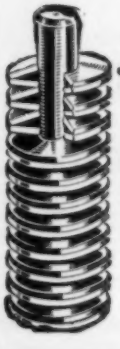
"QUALITY STAMPINGS IN SMALL QUANTITIES"

Why SCHNORR Disc Springs?



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5. Small constructional height, large deflection.
6. Large inherent damping.
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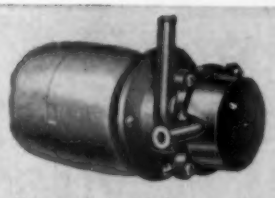
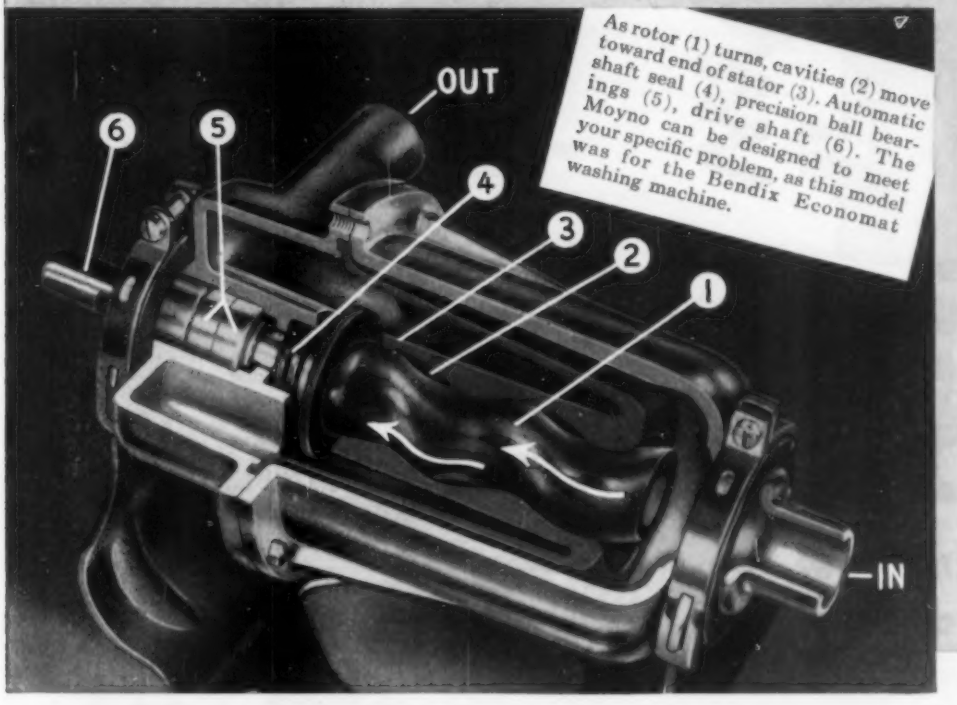


Moyno designed for pumping ethylene glycol, condensate from automatic driers, hot and cold water in dishwashers.

General purpose Moyno for pumping oils, water, alcohols and caustics.

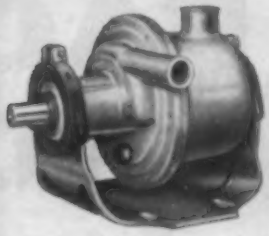
Bronze and stainless steel Moyno as used in a drink dispenser. Pumps water at more than 100 p.s.i.g.

Here's a compact version of a low head, small displacement Moyno for accurate pumping of small amounts.



As rotor (1) turns, cavities (2) move toward end of stator (3). Automatic shaft seal (4), precision ball bearings (5), drive shaft (6). The Moyno can be designed to meet your specific problem, as this model was for the Bendix Economat washing machine.

Versions of this compact Moyno are applicable as coolant pumps, shallow well pumps and booster pumps.



Economical Moyno for the appliance field, designed for use under flooded head.

BEFORE YOU "FREEZE" YOUR PRODUCT DESIGNS...

Read these FACTS about MOYNO® PUMPS!

One of these characteristics may improve YOUR product!

Versatile—Pumps liquids, pastes, abrasive-laden slurries. Adaptable to heavy industrial machinery or small drink dispensers, oil burners, dishwashers, sprayers, coolant pumps, etc.

Positive Displacement—Moynos are available to pull up to 29" of vacuum while discharging under pressure. Big Moynos can deliver up to 250 gpm. Pressures to 600 psi obtainable. Provide controllable, non-pulsating flow for metering purposes, in either direction!

Gentle—No churning, foaming; won't break up semi-solids. One Moyno is pumping potato salad!

Trouble-Free—Self-priming; won't cavitate or vapor-lock. Just one moving part—no valves to stick, no pistons to gum up. Low starting and running torque.

What you see here are seven variations of a *completely different concept of pump design* . . . the R&M "Moyno" Pump. It operates on a unique progressing-cavity principle, as shown by the large cutaway.

But even more important than how it works is how it *performs*. A good example is the Bendix Economat Washer, on which Moyno Pumps last *seven and a half times longer* than any pump tried before! On other types of applications—pumping everything from water, air, and abrasive-laden liquids to heavy, non-pourable pastes—users find that the simple Moyno Pump design saves maintenance dollars!

If you use pumps—and particularly if your pumping application is a little different—*there's a strong possibility that the Moyno can add new features to your product.*

New Bulletin No. 50-PD has more facts

Contains performance curves and details on pumping characteristics. Write for your free copy. If you can describe your application, we will be able to reply in even more detail.

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Electric Fans

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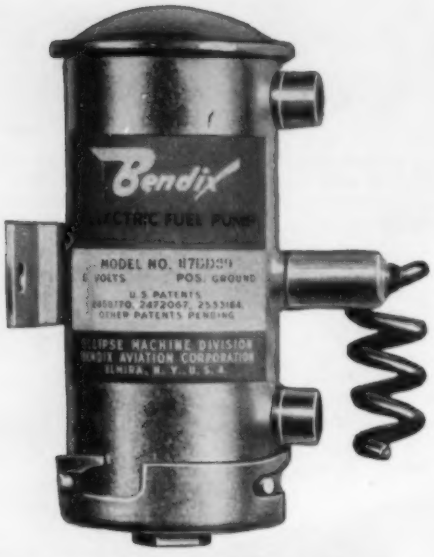
Moyno Pumps

Propellair Industrial Ventilating Equipment



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- **Built-in Pressure Release**
- **Eliminates Vapor Lock**
- **Delivers More Gallons per Hour**
- **Easy to Install • Easy to Service**
- **Low Power Requirements**
- **Economical Operation**
- **Light Weight • Compact**
- **Rugged • Tamper-proof**

Learn more about this new and improved fuel pump. Write for descriptive folder and specifications.

*REG. U.S. PAT. OFF.

ECLIPSE MACHINE DIVISION
ELMIRA, N. Y.

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40-page Illustrated Remote Control Catalog

Here is a valuable technical guide that can give you important background information toward solving your remote control problems. The various basic flexible and rigid control combinations, locking devices, fittings, etc., are shown together with information on the custom manufacturing of controls to your specifications.

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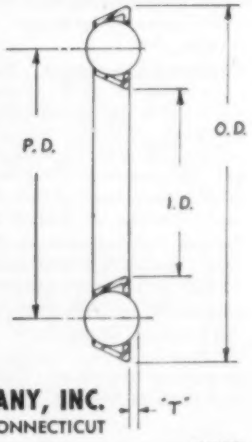
Prominent record player manufacturers sell "top performance," and get it by specifying Hartford thrust retainers with top quality Hartford precision chrome alloy steel balls. Positive spread of balls prevents cocking of shaft, insures precise "high fidelity" motion. Has low starting torque and minimum friction. Ready-made for quick assembly.



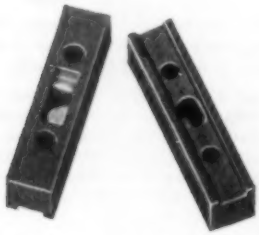
HARTFORD STEEL BALL COMPANY, INC.
HARTFORD CONNECTICUT

2H855

Making this intermediate wringer-drive gear of iron and copper powder saves the Whirlpool Corporation, St. Joseph, Michigan, up to $20,000 per year. The part was formerly made from a ⅜" blank which was pierced, flattened, machined for teeth; wire brushed for burr. Tolerances on the powder metal part are identical with those by machining.

The part shown is a card register block for IBM machines. Close dimensional tolerances are required as the part is used in a precision machine. The screw holes are tapped. As compared with machining the part represents a saving of approximately 82% in cost!

A valve disc sleeve used in the air release mechanism of a Neptune Red Seal petroleum meter was originally made of brass rod stock, then of die-cast zinc (which proved unsatisfactory) and now of powdered brass. Corrosion resistance is adequate; tolerances are ±.001" on two diameters. The part costs no more than the unsatisfactory die casting; approximately ⅓ that of the machined part.



Here are shown top and bottom of a powdered iron block that forms the structural base for the shearing head of a Schick Electric Razor. Dimensional stability is an important requirement. Powdered iron — replacing SAE 1020 steel bar stock—saves 7 machine operations and effects a saving of 50% in cost.

For Parts Like These... Powder Metal is a BIG Economy

Parts with involved contours that require multiple shaping operations . . . parts which cause heavy scrap losses . . . should be made of powder metal.

Brass, bronze, and iron powders, or mixtures, make powder metal parts at a single stroke to close tolerances . . . with coining to ±.001" . . . to tensiles of 70,000 psi . . . as high as 100,000 psi or more for special applications.

Stokes makes the presses that make the powder metal parts . . . offers you the experience of over 30 years in setting up for this modern, low-cost high-production method.

F. J. Stokes Machine Company, Philadelphia 20, Pa.

Another IBM part: This oil pump rotor is used in several IBM machines. Saving in cost as compared with a machined part, says IBM, is 84%! Total tolerances of .001" and .002" are required. Powder metal processing eliminates *all* machining operations, which previously required 20 hours per 100 pieces.

All the parts which illustrate this page are made by The Presmet Corporation, Worcester, Massachusetts, a custom supplier of high-precision powder metal parts. Like most powder metal parts producers, Presmet relies heavily on Stokes Presses.

STOKES

STOKES MAKES: High Vacuum Equipment, Vacuum Pumps and Gages / Industrial Tabletting, Powder Metal and Plastics Molding Presses / Pharmaceutical Equipment

Proof of *INCREASED PREFERENCE for WISCONSIN Heavy-Duty *Air-Cooled* ENGINES 3 to 36 H.P.

*Based on U. S. Bureau of Census Statistics, Wisconsin Motor Corporation leads the engine industry with 50.72% of total production in the 11 to 176 cu. in. displ. bracket — an industry-wide gain of 1.33%, as summarized below.

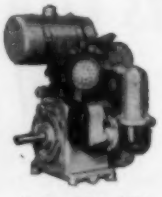
Once more U. S. Bureau of Census statistics provide authentic proof of outstanding preference for Wisconsin Heavy-Duty Air-Cooled Engines in the internal combustion engine field.

The latest "Facts for Industry" census report, released July 19, 1954, reveals the interesting fact that Wisconsin Motor Corporation produced 5,605 MORE engines in the 11 to 176 cu. in. displ. census grouping than ALL other internal combustion engine manufacturers combined, during 1953. This refers, of course, to engines built for re-sale, exclusive of automotive, aircraft, outboard, miniature and "captive" engines.

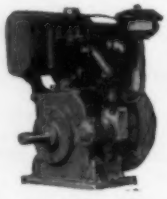
Translated into industry-wide percentages, census figures indicate that this company showed a gain of 1.33% over the combined production of all other engine builders. This, however, is an ultra-conservative figure inasmuch as the Wisconsin line covers a range of 13.5 to 154 cu. in. piston displacement whereas the Census Report grouping covers engines from 11 to 176 cu. in. displacement. In spite of this fact, Wisconsin Engine production amounted to 50.72% of the Industry's total in above grouping.

Statistically, these figures are interesting to us as evidence of consistent progress. To the Original Equipment Builder, Distributor and User of engine power, this report provides definite proof of INCREASED PREFERENCE for Wisconsin Heavy-Duty Air-Cooled Engines among people who are best qualified to judge comparative engine values in terms of performance, economy and low-cost maintenance.

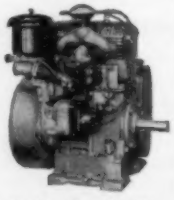
You can't go wrong if you specify WISCONSIN Engines for the equipment lines you *sell, build* or use.



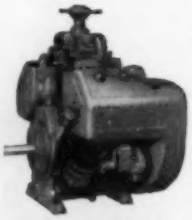
Models ABN, AKN, AEN, 4-cy. single cyl., 3 to 8¼ hp.



Models AFH, AGH, AHH, single cylinder, 6 to 9 hp.



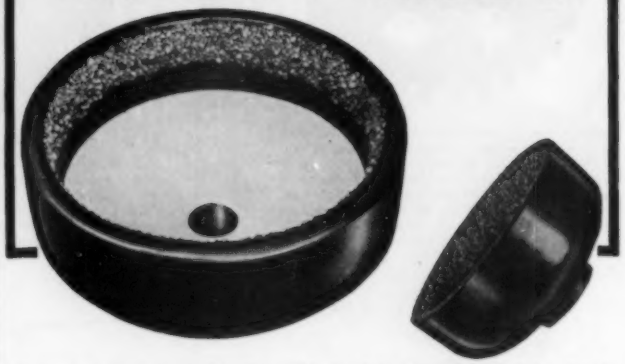
Models TE, TF, TFD 2-cylinder, 7 to 15 hp.



Models VE4, VF4, and VG4D, V-type 4-cyl., 15 to 36 hp.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

AN INSULATOR THAT PROVIDES A *GRIP!*



Made to customers specifications, this insulator has a sand lining fused to the inside to provide a strong, non-separating grip when it is cemented to a component part. The outside is finished in brown glaze.

Universal Porcelain Insulators are made to close dimensional tolerances, have uniform body density. They are high in physical and dielectric strength . . . withstand hot electrical arcing, thermal shock, vibration. They resist chemicals, moisture, fumes, heat and cold. And these characteristics remain unchanged during the life of the electrical unit in which they are used. Gain the advantage of Universal Porcelain on your next job! Our engineers are at your service.

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1545 EAST FIRST STREET — SANDUSKY, OHIO
TRADE MARK

Improve your product's appearance with . . .

ELECTROLYTIC AND CHEMICAL COATINGS

8 pages — 25 cents a copy

This Special Editorial Report covers classes and types of electrolytic and chemical coatings . . . how base metal affects selection . . . appearance and protective finishes . . . new development and industry trends . . . and examples showing how your products will look. Included is a comprehensive chart analysis of all types of organic, inorganic, and specialty finishes for the major metals.

Copies of other reports in *Product Engineering's* series of full-color articles covering product improvement through better surface appearance and protection are also available. Write for an editorial reprint order form, listing titles and costs.

READER SERVICE DEPARTMENT

Product Engineering
McGraw-Hill Building, New York 36, N. Y.

is there a "STOCK" answer to your "SPECIAL" gauge problems?

There may very well be, because USG manufactures and stocks more than 200,000 standard gauges and a complete line of gauge components to meet practically every pressure sensing and indicating requirement.

For over 50 years USG gauges have won acceptance for their high accuracy and dependability—more original equipment manufacturers specify USG than any other make...a tribute to their acceptance by industry.

Your USG Distributor has on his shelves, or can get for you fast, any quantity of gauges you want for any application. See your USG Distributor or call the factory for all your gauge requirements.

UNITED STATES GAUGE *Gauge Headquarters for over 50 years*

United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Penna.

MANY USG STOCK GAUGES ARE "SPECIALS" WITH OTHER MAKERS

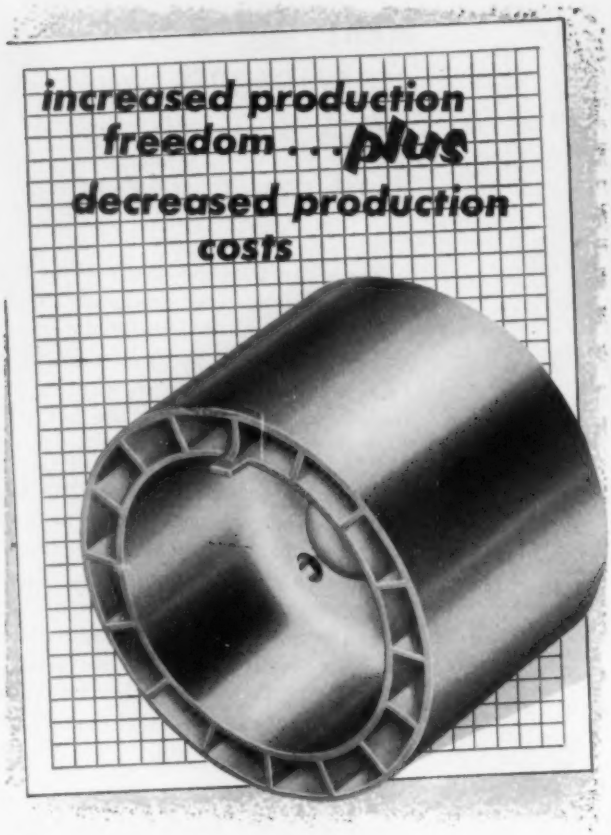
For more than 50 years USG has been designing and producing many "special" gauges for industrial applications. Through the years many of these "specials" gained wide acceptance and have become standard in the industry ... and stock items at USG.

Many of these more than 200,000 finished stock gauges in USG's stock room would be expensive "special" production items with other instrument manufacturers. In addition to this tremendous finished stock USG also maintains an inventory of component parts which can be readily assembled into a wide variety of "special" gauges ... *practically at stock costs.*

Users of these USG gauges are assured of highest quality in every price class through USG's rigid quality control system. This constant testing of component materials is just one of the many reasons why USG gauges are world-renowned for their unfailing accuracy and dependability.

USG also maintains a Research Laboratory where extensive research is carried on to continuously verify the behavior of gauges under the most rigorous operational and environmental conditions. Annually, these tests save USG customers hundreds of thousands of dollars by eliminating the need for frequent gauge replacements.

This illustration shows a run of USG gauges being subjected to a pressure cycling test which simulates exaggerated service conditions. The unique "whip" test relieves the tube of stresses and strains and assures long service life and unchanging accuracy.



As much as 81% saved on intricate Arwood Investment Castings

Unlimited freedom of design and substantial savings are by-products of the Arwood investment casting process. Applications are virtually limitless, with many former sub-assembly jobs now being cast as single units. Moreover, complicated parts can now be cast in unmachinable alloys.

Our engineers will be pleased to go over your parts problems with you and help cut your own costs. Why not submit parts or prints to us for quotations? Consultation is free of obligation, of course.

Write for free literature describing the investment casting process.

CASE STUDY

DESIGNATION: Impeller for flowmeter.
METAL: Magnesium, Dowmetal C.
QUALITY CONTROL: Produced under radiographic control.
PARTS: Designed and cast as single unit.
ADVANTAGES: Fine grain and smooth surfaces. Annular passages without draft. Now standardized because of top quality at bottom cost.

ARWOOD

PRECISION CASTING CORP.
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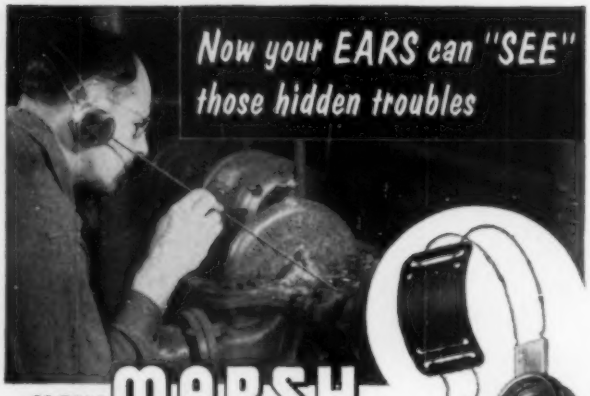
PLANTS: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.



NEW MARSH
Serviceman Soundscope

. . . cuts servicing and maintenance costs

Most effective instrument ever developed for pin-pointing and identifying mechanical defects. Saves time and dollars tracking down troubles in bearings, gears, mechanisms . . . detects leaks, knocks, piston slaps—any defects that make a sound. A precision instrument of Marsh quality, sensitive to faintest sounds . . . with handy probe and headband as illustrated. A remarkable tool, moderately priced.

Ask for Circular

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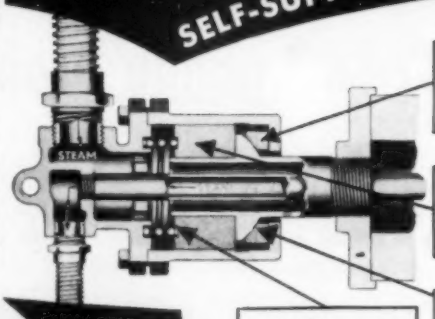
Sales Affiliate of Jas. P. Marsh Corporation
Dept. 39, Skokie, Illinois
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada

JOHNSON Rotary Pressure JOINT
SELF-SUPPORTING TYPE



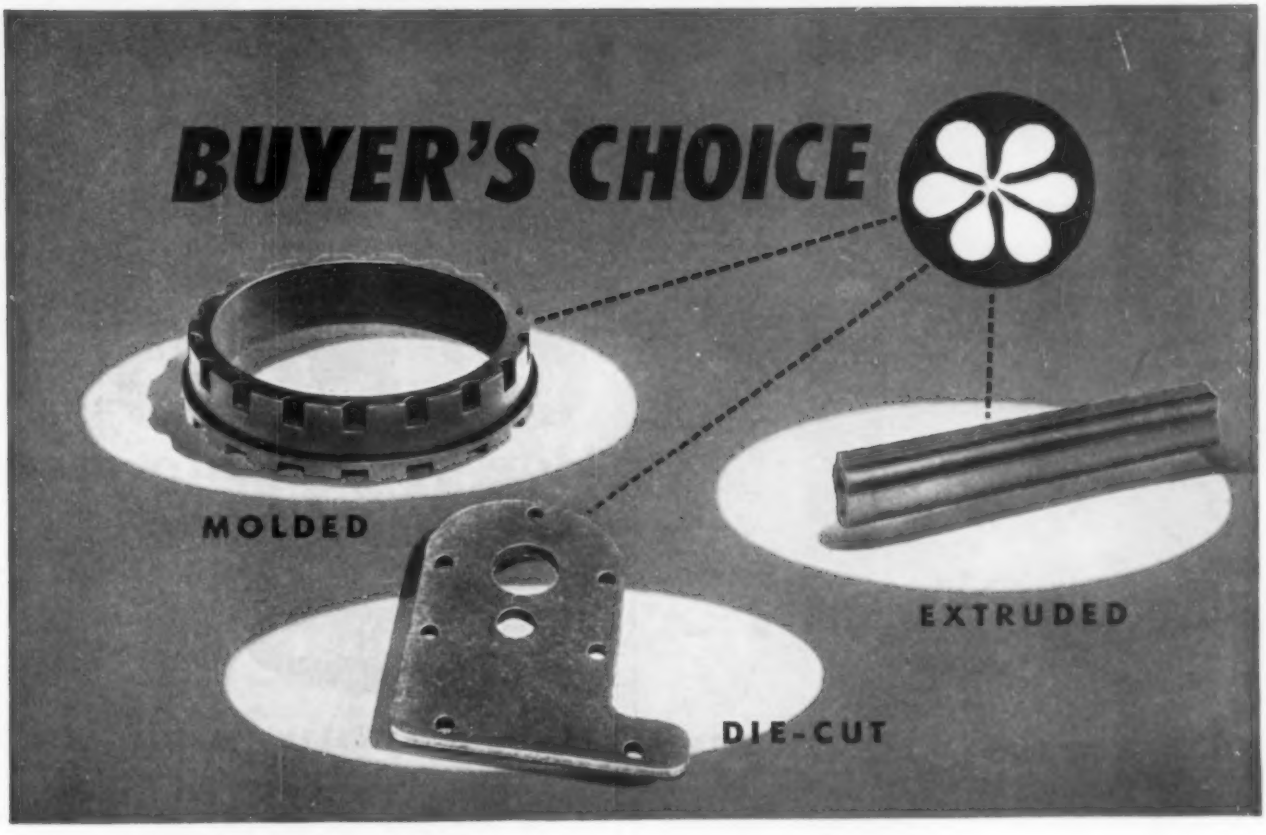
1. **SEAL RING** — of special carbon-graphite. Eliminates packing and oiling.
2. **GUIDE** — Also of carbon-graphite. Makes joint self-supporting.
3. **NIPPLE** — Rotates with roll, seals against ring.
4. **SPRING** — For initial seating only. In operation joint is pressure sealed.

Only 4 Internal Parts

For introducing steam and liquids into rotating rolls and cylinders, there's nothing like the Johnson Joint above. It's packless, self-lubricating, self-adjusting, self-supporting. It has been adopted by dozens of machinery makers, and is finding new uses every day.

Type SB shown handles both steam and condensate through same head; also available for through flow service, and in sizes and styles for all operating conditions. ***Write for literature.***

The Johnson Corporation
812 Wood St., Three Rivers, Mich.



*ACADIA SYNTHETIC RUBBER PARTS ARE MADE ALL 3 WAYS!

With Acadia you have a *choice!* Not only molded rubber . . . not only molded and die-cut . . . not only extruded rubber . . . but rubber parts any way you require! Better yet, Acadia uses whatever method the requirements of the job and you dictate is the *best* way to do it.

Acadia is especially sensitive to your specifications. We will process synthetic components for oil-resistance — good aging properties — resistance to heat — any characteristic you're seeking, or a combination of characteristics. Acadia parts are cut, molded or extruded to all required shapes, sizes and types, with almost unlimited applications.

Also, we offer Acadia SILICONE Rubber, molded or extruded for gaskets, seals, "O" rings, washers, sheets, cut-parts and packings. This is the rubber that will stay resilient at 100° *below* zero, or 500° above!

There's an Acadia Sales Engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA Synthetic PRODUCTS

DIVISION OF WESTERN FELT WORKS

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MAYLINE

for the Very Best in Drafting Furniture specify MAYLINE

4 POST TABLE WITH DRAWERS

Mayline's fine drafting furniture is reasonably priced, quality is high.

Inquire of your dealer or write for catalog 8A.

METAL PLAN FILE WITH HINGED COVER

Symbol of MAYLINE *Superiority*

MAYLINE CO.
605 NO. COMMERCE ST.
SHEBOYGAN, WISCONSIN

V-MODEL TABLE WITH FOOTREST

MAYLINE

MAYLINE

MAYLINE

Stock molded plastic parts by **DIMCO-GRAY**

NO TOOL CHARGE!

PROMPT DELIVERY ON . . .

Terminal Nuts	*Round Ball Knobs*
Oval Ball Knobs	*Lid Knobs*
Instrument Knobs	*Knurled Hand Wheels*
Knurled Knobs	*Tapered Handles*
Push Button Knobs	*Agitator Caps*

Standard Army-Navy Instrument Knobs and Terminal Boards

DWG. NOS. 46A42258, 47A40527, 46B42258, 50B13030, 46B42249, 49B14919.

Write for Complete Catalog!

DIMCO-GRAY COMPANY
206 EAST SIXTH STREET • DAYTON 2, OHIO

How to keep informed on the "with what" part of your business

AT YOUR FINGER TIPS, issue after issue, is one of your richest veins of job information – advertising. You might call it the "with what" type – which dovetails the "how" of the editorial pages. Easy to read, talking your language, geared specifically to the betterment of your business, this is the kind of practical data which may well help you do a job quicker, better – save your company money.

Each advertiser is obviously doing his level best to give you helpful information. By showing, through the advertising pages, how his product or service can benefit *you* and *your* company, he is taking *his* most efficient way toward a sale.

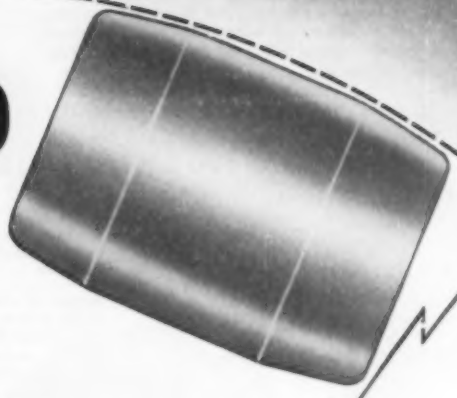
Add up all the advertisers and you've got a gold mine of current, on-the-job information. Yours for the reading are a wealth of data and facts on the very latest in products, services, tools . . . product developments, materials, processes, methods.

You, too, have a big stake in the advertising pages. Read them regularly, carefully to keep job-informed on the "with what" part of your business.

McGRAW-HILL PUBLICATIONS

McGRAW-HILL FOR BUSINESS

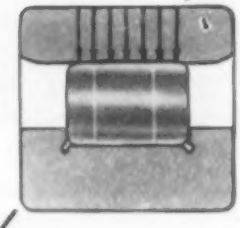
NOW... all Tru-Rol Bearings *have* CROWNED ROLLERS



● When a straight cylindrical roller bearing is under load, the highest stresses tend to concentrate at the roller ends. Stresses may become excessive and cause early bearing failure.

Crowning is a Rollway grinding refinement that adds a long radius curve to the roller ends. This relieves the high stress areas — allows the rollers to take heavier loads and reduces the effect of slight shaft misalignment or deflection. Bearings can be load rated at substantially higher values — provide a longer service life.

Crowning is but one of the many engineering advances built into Rollway Tru-Rol Bearings. Write for the complete story. Rollway Bearing Co., Inc., Syracuse, N.Y.



Crowned roller under full load — stress uniformly distributed.

Carefully selected crown radius, varying from 20" to 260", provides proper relief for normal loading to which bearing will be subjected.

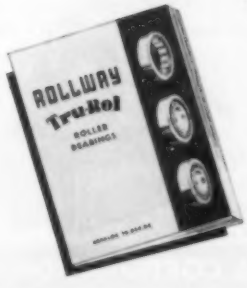
Crowned Tru-Rol Bearings available in the following type:

Full Roller

Segmented Steel Retainer

+

Stamped Steel Retainer with Guide Lips



New Rollway Tru-Rol Catalog features RBEC formula converted to simple nomogram. Send for your copy today.

ROLLWAY BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

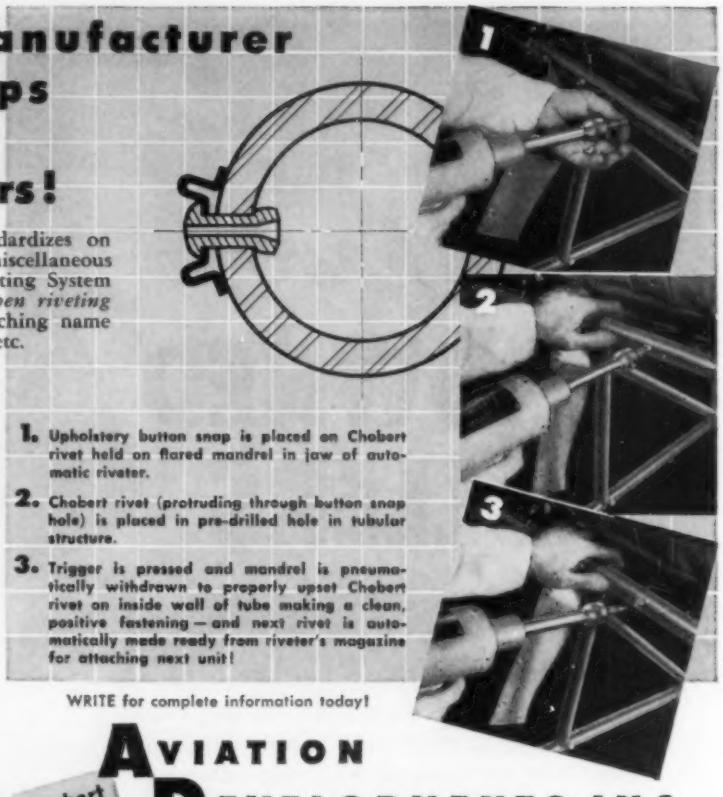
SALES OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • Philadelphia • San Francisco • Boston • Detroit • Pittsburgh • Milwaukee • Houston • Los Angeles

how another manufacturer saves production steps with CHOBERT rivet-type fasteners!

TECO, Inc., leading airline seat manufacturer, standardizes on Chobert rivets for many sheet metal assembly and miscellaneous fastening requirements. The Chobert High-Speed Riveting System is especially designed for *fully-automatic blind or open riveting* of structural and non-structural assemblies and attaching name plates, identification tags, breather and filter screens, etc.

problem: *To find a faster, easier way to attach upholstery button snaps to tubular seat frame and reduce number of hand operations required by self-tapping screws, nuts, bolts and pins.*

answer: *Fully-automatic "repeater action" Chobert riveter and rivet-fasteners make a complete fastening at the press of a trigger — as shown in the accompanying sequence illustrations — prove to be the complete answer!*



1. Upholstery button snap is placed on Chobert rivet held on flared mandrel in jaw of automatic riveter.
2. Chobert rivet (protruding through button snap hole) is placed in pre-drilled hole in tubular structure.
3. Trigger is pressed and mandrel is pneumatically withdrawn to properly upset Chobert rivet on inside wall of tube making a clean, positive fastening — and next rivet is automatically made ready from riveter's magazine for attaching next unit!

NO SKILLED HELP REQUIRED

The Chobert High-Speed Automatic Riveting System gives top results even with unskilled help. A wide variety of Chobert rivet styles and sizes are available and magazine loading of pneumatic riveter is fast and simple. A single gun can set up to 2000 rivets per hour. Pressing the trigger pneumatically withdraws flared mandrel which forms the rivet "tail" giving a uniform positive grip.

WRITE for complete information today!

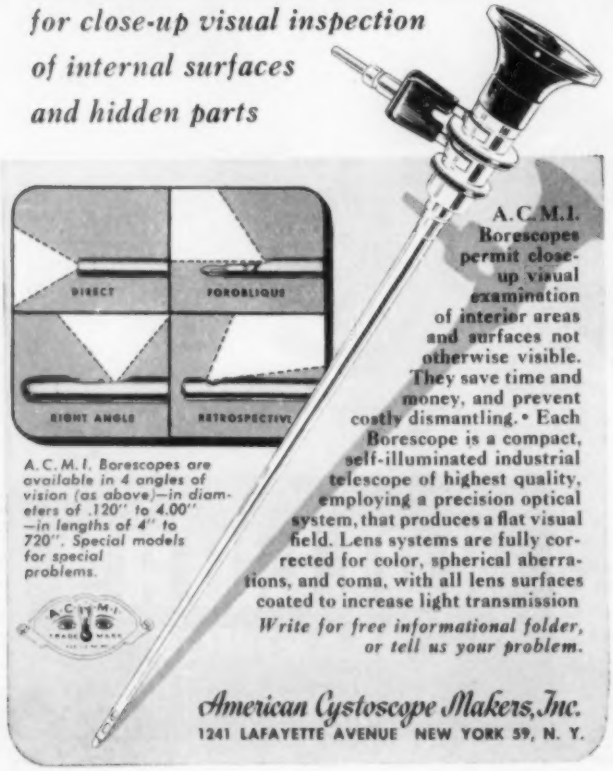
chobert AVIATION DEVELOPMENTS INC.

210 SOUTH VICTORY BLVD. | BURBANK, CALIFORNIA

AVIATION DEVELOPMENTS (CANADA), LTD., TORONTO | AVIATION DEVELOPMENTS, LTD., LONDON, ENGLAND

A.C.M.I. BORESCOPES

for close-up visual inspection of internal surfaces and hidden parts



A.C.M.I. Borescopes are available in 4 angles of vision (as above)—in diameters of .120" to 4.00"—in lengths of 4" to 720". Special models for special problems.

A.C.M.I. Borescopes permit close-up visual examination of interior areas and surfaces not otherwise visible. They save time and money, and prevent costly dismantling. • Each Borescope is a compact, self-illuminated industrial telescope of highest quality, employing a precision optical system, that produces a flat visual field. Lens systems are fully corrected for color, spherical aberrations, and coma, with all lens surfaces coated to increase light transmission

Write for free informational folder, or tell us your problem.

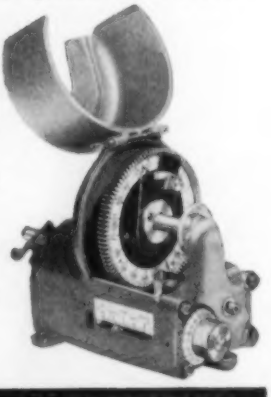
American Cystoscope Makers, Inc.

1241 LAFAYETTE AVENUE NEW YORK 59, N. Y.

Have you considered this AID for AUTOMATION ?

CYCLO-MONITORS:

1. **PRE-SET** over a wide range of numbers. No tools required.
2. **COUNT** shaft revolutions, lever strokes or electric impulses.
3. **TRANSFER** a built-in single pole, double throw control switch.
4. **HOLD** switch in transferred position for a controlled interval.
5. **RETURN** switch to normal position.
6. **REPEAT** automatically—with absolutely no interruption of the counting process. No lost counts or time lag.



CYCLO-MONITORS are available in many forms—including models arranged for your special requirements.

Write for Bulletin 202-1

COUNTER & CONTROL CORPORATION

5221 W. ELECTRIC AVE. • MILWAUKEE 14, WIS.

"...through a person-to-person canvass..."

ROBERT S. MACFARLANE
President
Northern Pacific Railway Company

"Combine a good product with enthusiastic salesmanship, capably directed, and favorable results are reasonably certain. This winning combination through a person-to-person canvass recently added more than 8,000 employees of the Northern Pacific Railway to the Payroll Savings Plan for purchase of U. S. Savings Bonds. It is gratifying to me that the organized efforts of Northern Pacific personnel not only have resulted in substantially increased systematic saving and a greater investment in America's future by our employees, but that the Treasury Department is using our campaign as an example throughout the railroad industry in its efforts to step up regular purchases through payroll deductions."

The U. S. Savings Bond *is* a good product . . . Payroll Savers *are* enthusiastic Bond Salesmen . . . company spirit *was* good because everybody on the Road knew that Mr. Macfarlane was 100% behind the effort to increase employee participation in Northern Pacific's Payroll Savings Plan.

But, there was still another, and very important, factor in the success of Northern Pacific's campaign that added more than 8,000 new Payroll Savers — a Person-to-Person Canvass.

A good Person-to-Person Canvass is an organized employee effort that puts a Payroll Savings Application Blank in the hands of every man and woman in the company. There is no pressure, no drive to "sign up." Every employee is free to make his own decision. That's all there is to a Person-to-Person Canvass, but in literally thousands of companies, as on the Northern Pacific, a high percentage of employees *want* to build their personal security and are quick to join the Payroll Savings Plan when its availability and many advantages are brought to their personal attention.

Upwards of 8,000,000 employed men and women are enrolled in the Payroll Savings Plan, most of them as a result of Person-to-Person Canvasses. Each month these Payroll Savers invest more than $160,000,000. The 1954 goal is 9,000,000 Payroll Savers. It can be reached if you and other executives will take a personal interest in the Plan and what it means to your employees, your company and your country.

If your company has the Payroll Savings Plan your State Director will be glad to help you organize a Person-to-Person Canvass that should increase employee participation to 50%, 60% or more. If you do not have a plan he will show you how easy it is to install one. Write to Savings Bond Division, U. S. Treasury Department, Washington, D. C.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

Product Engineering

SEARCHLIGHT SECTION

(Classified Advertising)

EMPLOYMENT: BUSINESS: **"OPPORTUNITIES"** :EQUIPMENT :USED OR RESALE

UNDISPLAYED —RATES— DISPLAYED

(Not available for equipment advertising)

$1.50 a line, minimum 4 lines. To figure advance payment count 5 average words as a line.

Individual Employment Wanted advertising rate is ½ the above rate, payable in advance.

Box Numbers—Care of publication New York, Chicago or San Francisco offices as one line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Individual Spaces with border rules for prominent display of advertisements.

The advertising rate is $15.10 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

New advertisements received in the N. Y. C. office by Jan. 20th will appear in the February issue.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (36)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

FACTORY MANAGER

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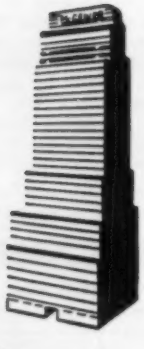

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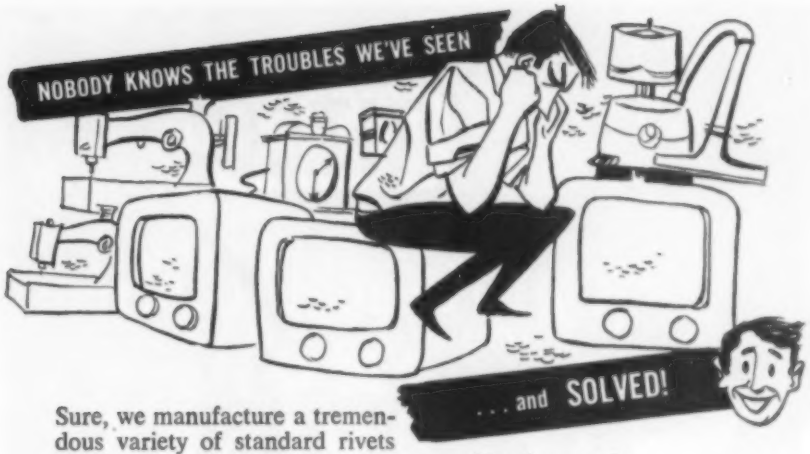

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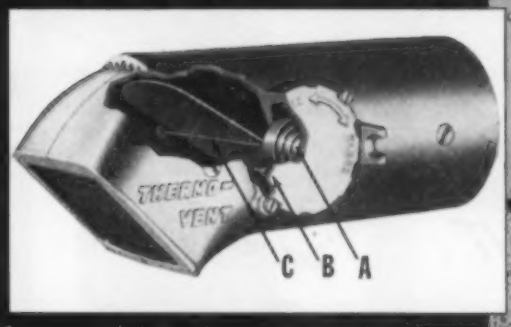

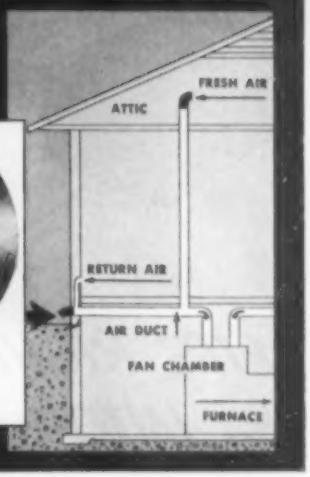

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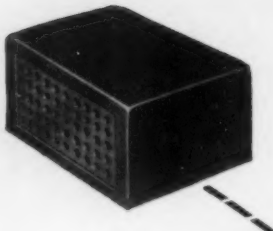

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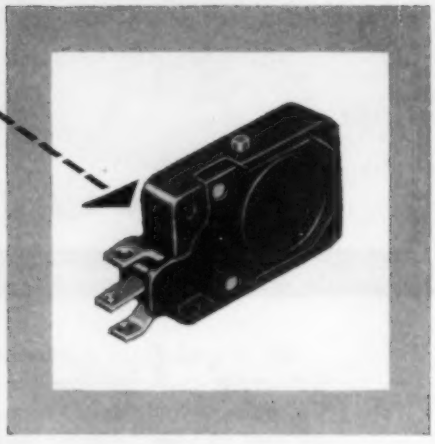

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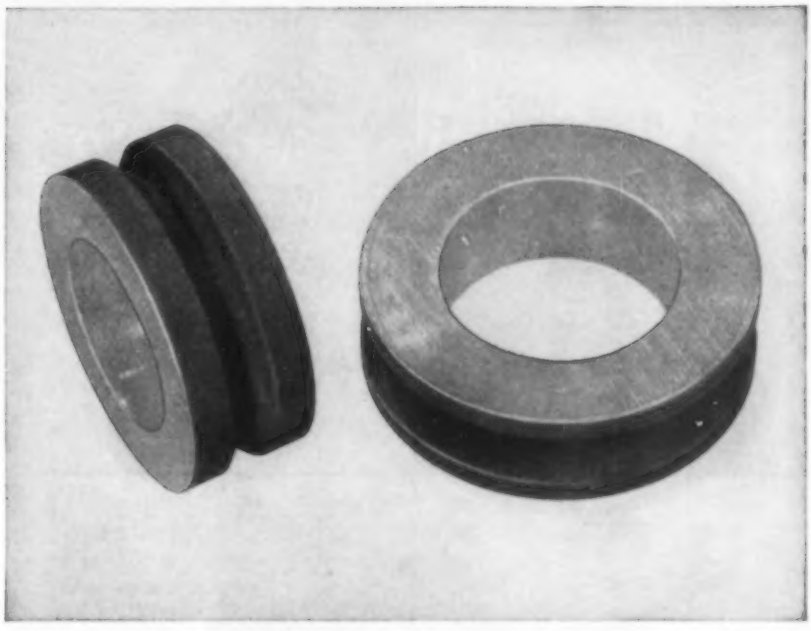

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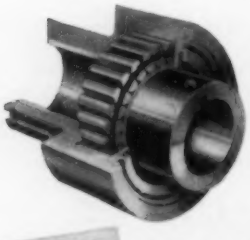

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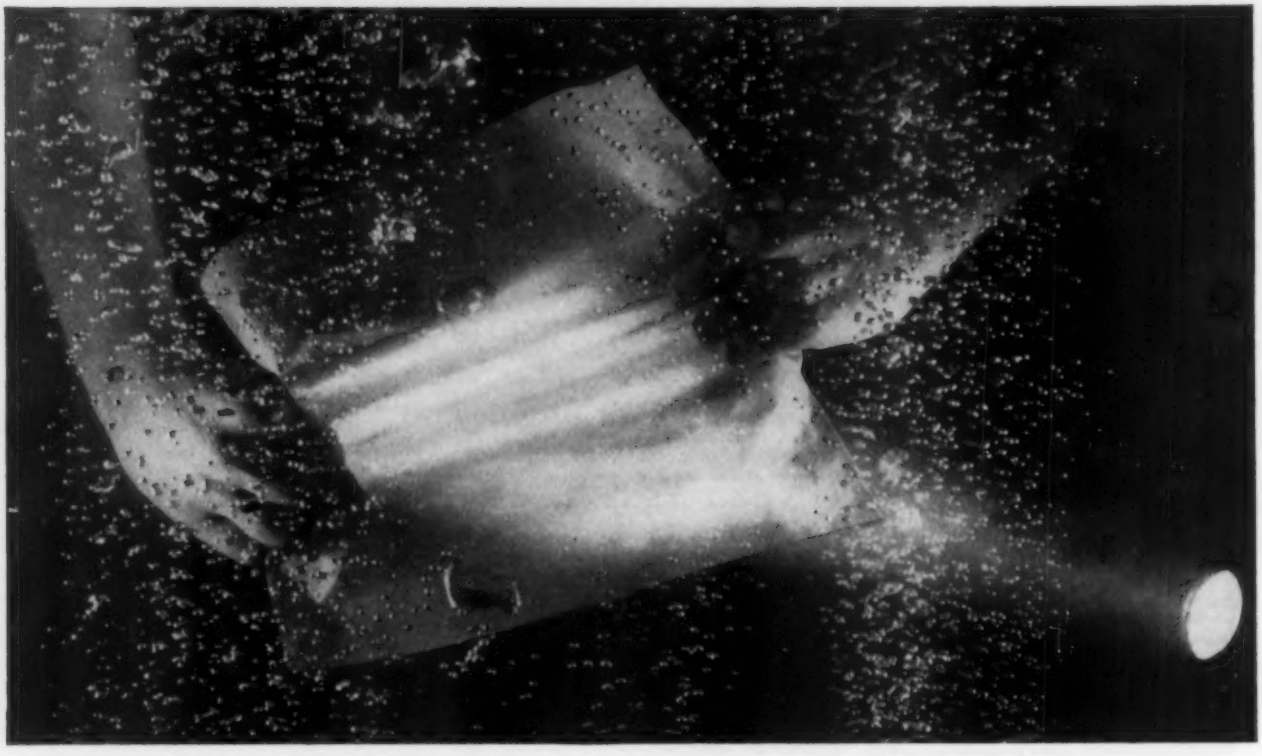

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240b	241	242	243	244	245	246	247	248	249	250	251	252	253
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325	326	327	L328	R328	329	T330	BL330	BR330	331	L332	R332	333	L334
TR334	BR334	335	L336	TR336	BR336	337	L338	339	L340	341	L342	TR342	BR342
343	L344	R344	345	L346	R346	347	TL348	BL348	349	350	351	352	353
354	355	R356	TL356	BL356	357	T358	BL358	BR358	359	L360	TR360	BR360	361
L362	TR362	BR362	363	L364	TR364	365	L366	TR366	BR366	367	TL368	BL368	369
T370	BL370	BR370	R375	L376	R377	L378	R379	L380	R381	384	C3	C4	

. . . NEW PRODUCTS . . .

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. . . NEW BULLETINS . . .

CIRCLE THESE NUMBERS FOR COPIES OF NEW BULLETINS LISTED IN THIS ISSUE

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. . . SPECIFIC DATA . . .

Card expires March 1

128—Roll Shafts
139—Geared Joint
140—Steam and Air Traps
141—Air-Operated Clutch
142—Fluid Power Equipment
143—Cam Clutches
144—Rotary, Multiple Switches
145—Electrical Relays
146—Counting Machines
147—Overhead Conveyor Trolley
148—Air-Powered Solenoid Valve
149—Liquid Polymer Compounds
150—Reproduction Materials
151—Shock and Vibration Isolators
152—Plastic Pipe, Fittings, Valves
153—Silencers, Snubbers
154—Electrical Switch
155—Chain Coupling
156—Packing, Gaskets
157—Stainless Steels
158—Power Transmission Equipment
159—Chrome-Nickel Steels
160—Wire Rope Assemblies
161—Aluminum Designation System
162—Lock Nuts
163—Wafer Capacitors
164—Cork Products
165—Pilot-Type Relief Valves
166—Direct-Drive Fan Motors
167—Stainless Steel Gate Valves
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Grinds breech of 4,000 lb. gun barrel

TIMKEN® bearings on work spindle hold runout within .0007"

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Due to their tapered construction, Timken bearings take radial and thrust loads in any combination. Spindles are held rigid, runout doesn't exceed .0007". And because of line contact between the rollers and races, Timken bearings have capacity to spare.

Both Timken bearings on the work spindle are mounted with cone spacers so that no manual adjustment is necessary. Spindle maintenance is simplified. And Timken bearings practically eliminate friction because they are geometrically designed to have true rolling motion and precision manufactured to live up to their design.

The end of the work spindle may possibly be bumped by the long, heavy gun tube when chucking a new piece. Timken bearings stand up to these shock loads because the rollers and races are case-hardened. This gives them hard, wear-resistant surfaces over tough, shock-resistant cores. What's more, we make our own steel to check quality every step of the way. No other U. S. bearing maker does.

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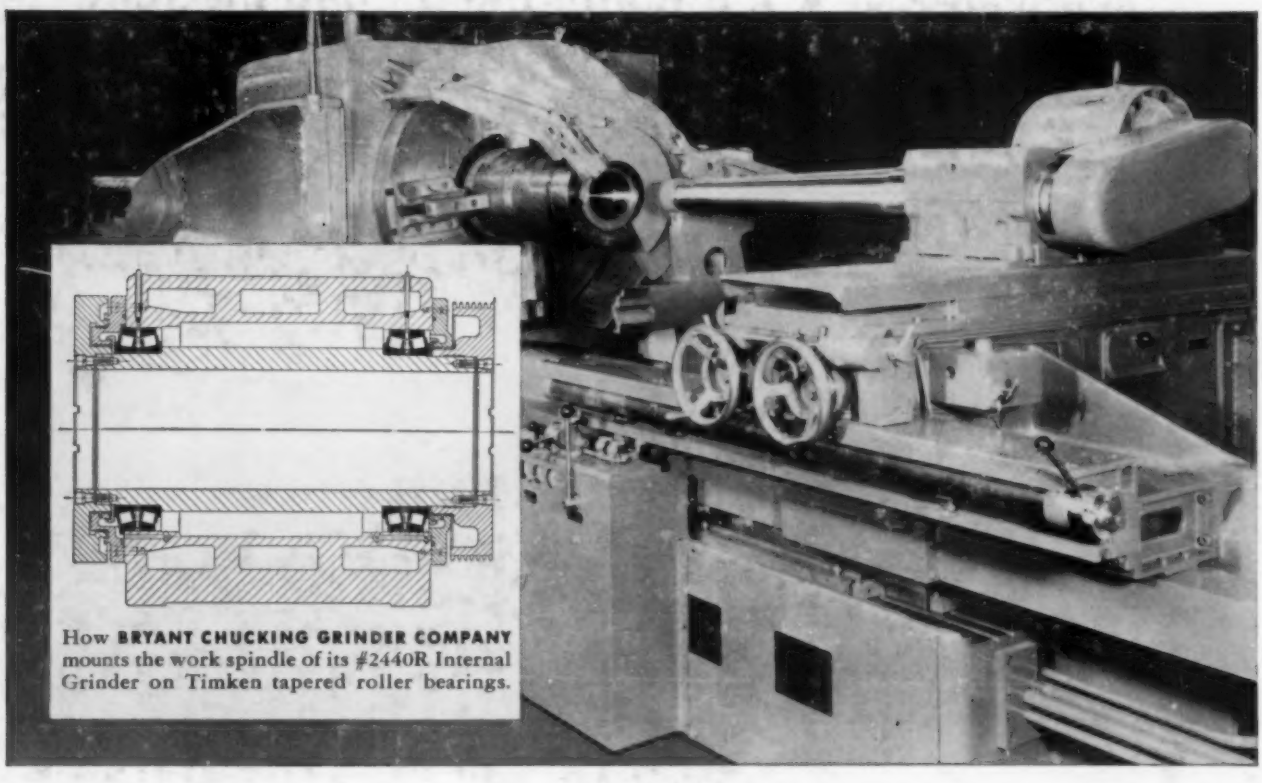
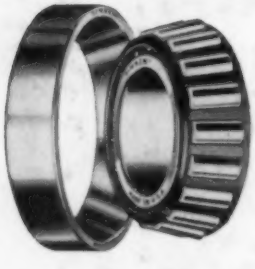
This symbol on a product means its bearings are the best.



How **BRYANT CHUCKING GRINDER COMPANY** mounts the work spindle of its #2440R Internal Grinder on Timken tapered roller bearings.



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